STATE MEDICINE

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LECTURES

ON

STATE MEDICINE

DELIVERED BEFORE THE

SOCIETY OF APOTHECARIES

AT THEIR HALL IN BLACKFRIARS

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BY

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ON

STATE MEDICINE.

LECTURE I.

PRELIMINARY—SKETCH OF THE HISTORY OF SANITATION IN THIS COUNTRY.

Master, Wardens, and Gentlemen,

Your Society, having determined to institute a limited course of lectures on State Medicine, has done me the honour of entrusting the task to me. It was not without considerable diffidence that I undertook it, knowing, as I did, that it was beset with difficulties which I might not find easy to overcome. The subject is one of such extent, and so scattered over books and papers, that the mere time required for the collecting of material was a serious consideration. Again, it must be the experience of all who have tried it that it is infinitely more difficult to give a clear and telling *précis* of a subject than to write with prolixity and diffuseness, whilst on the other hand long lectures and a protracted course could have but one result, namely, weariness and

disappointment to my hearers. In considering therefore the direction that my remarks should take I have thought that the purpose of the Society would be best accomplished by giving a brief sketch of what has been done in the way of sanitation up to the present time, with reference to the labours of those honourable pioneers to whom we of this day owe so much, and comparing shortly the existing condition of our community with what we know of it in comparatively pre-hygienic times. Following upon this would come the consideration of the special divisions of hygiene as they affect the public health, and the duties of the state with regard to them.

It is a happy augury for the future of our race that the subject of public health has at last taken a pretty firm hold upon the public mind, although we have still to battle with much opposition, the chief giants in our path being ignorance, vested interests, and the liberty of the subject. The true knight who shall make an end of these is knowledge, led by the hand of time. More extended and compulsory instruction in our schools must be continually urged, so that the habit o understanding biological subjects shall become more or less inherited, and at length, by persistent iteration, questions that appear now to present insuperable difficulties find a ready solution in the most ordinary minds. Much may be done in this direction, particularly where correct principles are inculcated in the truly plastic period of the youthful mind ; and on this subject I may quote a remark by Professor Sylvester, in his 'Plea for the Mathematician.'

'As a public teacher of mere striplings, I am often amazed by the facility and absence of resistance with which the principles of the infinitesimal calculus are accepted and assimilated by the present race of learners. When I was young, a boy of sixteen or seventeen who knew his infinitesimal calculus would have been almost pointed at as a prodigy, like Dante as a man who had seen hell. Now-a-days our Woolwich cadets at the same age talk with glee of asymptotes and points of contrary flexure, and discuss questions of double maxima and minima, or ballistic pendulums, or motion in a resisting medium, under the familiar and ignoble name of *sums*.'

Now if so much can be done in one branch it may be done in another, and, if the problems of life and health were made the objects of talk and study, they would infallibly, by force of habit, if of nothing else, become fixed as principles in the minds of the rising generation. It is true that we have this difficulty that it is less easy to dogmatise in sanitary instruction than in mathematics, and for the young some dogmatic teaching is necessary; still there are principles sufficiently certain and fixed to form a tolerably sure foundation for some greater superstructure in the future. Before such extending knowledge, the old enemy, vested interest, would disappear like ice before the returning sun, whilst men would also learn that the truest liberty is that which emancipates them from every thraldom, both moral and physical, whose oppression tends to oppose the increasing progress and happiness of the human race. When such a consummation is

reached, the interference of authority and legislation will no longer be required or thought of. To a man whose principles, habits, training and social position put him above the tendency to commit any of those grosser crimes for which the law has prescribed penalties, the existence of controlling legislation on those points is a matter of no personal consideration. He does not complain that his personal liberty is interfered with because he knows he will be hanged if he murders his neighbour; the fact is, he does not want to murder his neighbour, and in all probability he never will do so. But it is decidedly important for him that his neighbour should be restrained from murdering him, and accordingly some sort of legislation of a repressive character becomes necessary. That this may be carried too far the history of our own criminal annals shows only too well. In the lifetime of some still living, Draco was the only model: small crimes were adjudged worthy of death, and there was no greater one for great ones. But no intelligent student of sociology will maintain now-a-days that men were hanged, drawn, and quartered into a higher morality, and that the comparative security for life and property now are due to the severity with which justice was dispensed in former times. On the contrary, the existing happier conditions under which we live have been due to a softening of manners and habits of thought by the diminution of ignorance and by the general improvement of the well-being of the people. In the meantime it must be admitted that some legislation was and is still necessary pending the

improvement referred to, and that, although error in the direction of excess unquestionably took place, it was error of the kind to be expected while human nature lasts. All legislation is merely, as it were, a stopgap, while the people, whose welfare is the object of it, are being gradually trained to do without; it is in fact a confession *pro tanto* of how far the community falls short of a desiderated ideal. Accordingly the often-quoted and much-abused expression that it is impossible to make people 'virtuous by Act of Parliament,' has both right and wrong on its side. It is certainly impossible if the Act of Parliament is looked upon as a finality, and not as a more or less imperfect means to an end. Imperfect as it is, however, it must still be recognised as the summation of the better reason of the enlightened few for the guidance of the ignorant many, with a view to saving the community from the consequences of its own ignorance, while it is being gradually trained up to a higher and a nobler life. Such reflections especially suggest themselves when we consider the complex question of State Medicine. State Medicine has been written about, talked about, and quarrelled about, but it has rarely been explicitly defined, and to many it conveys no very distinct idea. It has been confounded with Public Health, and generally much misunderstood, the part being frequently taken for the whole, and the wider scope of its action but little apprehended. It includes the questions of public health and hygiene, general, special, and individual, but its own appropriate province is such general control as will determine the several

specialities in the directions most fitted for the well-being of the community. In fact we may succinctly define State Medicine to be, in quasi-legal phraseology, 'The office of the Sanitarian promoted by the State,' and it will have both reached its perfection and extinguished itself when both Sanitarian, as differentiated from the community generally, and State, as a controlling and interfering influence, shall have ceased to be; the one because every member of a perfected community will be a sanitarian in the best and truest sense of the word, and the other because, from the very condition of the community, State interference will have become perfectly unnecessary. This is the ideal towards which we must work, not that either we or our children's children are ever likely to see it, but that by continual striving after so high an end we may imperceptibly diminish the distance in course of time, and make the way by so much the shorter for generations yet unborn.

The *periods* through which a people passes in its hygienic history may be summarised as follows:—

1. *The instinctive period*: when the man is in the rudest state of savagery, not much removed from the brutes. This passes gradually into

2. *The supernatural period*: when disease is looked upon as the direct act of an offended deity. Of course there are various gradations of this stage, according to the more or less exalted ideas entertained of the supreme power; and it slowly emerges into

3. *The rational period*: when disease is recognised as the result of physical causes, that admit of being enquired into and dealt with in a scientific manner.

But this last grand division requires to be further divided, and accordingly we may consider it to be made up of:

I. *The stage of development*: during which the principle of rationalism struggles for expression and recognition.

II. *The stage of legislation*: during which the wisdom of the few is applied to frame laws for the benefit of the community. The earliest indication of this stage is to be found in severely repressive laws and in enactments to meet emergencies, but without any thought of comprehensive legislation.

III. *The stage of freedom*: when the laws of health and progress shall be as clearly understood as those of arithmetic, and the practice of them become so much of a second nature as to render repressive legislation obsolete and useless. This final stage can only be hastened by the character and nature of the work done in the previous one, not so much in the way of repressive legislation as in active encouragement to the spread of knowledge of the most useful kind; by the widest incentives to scientific research in every direction, by placing the means of acquiring knowledge of all kinds within the reach of every one, and above all by inculcating true principles on the minds of the young, and fostering everywhere the desire to learn and improve. We in this country have (not altogether, it is true, for overlapping does take place) emerged from the supernatural period, and have fairly entered upon the rational for a good many generations. The labours of the great workers of the sixteenth and seventeenth cen-

turies paved the way for the extraordinary march of improvement in the eighteenth in which discovery followed discovery in science, and the labours of Lind and Pringle, Howard, Jenner, and many others, both in this country and abroad, so successfully carried on the stage of development that almost in their own time they beheld the stage of legislation upon which we ourselves have entered.

The first general enactment of importance appears to have been the Factory Act in the reign of George III., which however remained comparatively inoperative and had to be ultimately replaced by the Act of William IV. in 1833, the consequence of a Royal Commission of Enquiry issued in the previous year. Apart from this, however, general legislation for the community appears to have been but little attempted, although Acts, local in character, gave powers to municipal bodies to provide water supply and drainage and to deal with nuisances of different kinds. The distress following the great war with France, the high price of necessaries, the financial crisis of 1825, and the increasing pauperism of the kingdom, all contributed to the passing of the Poor-Law Amendment Act of 1834, which unquestionably opened the way to much improvement, both morally and physically, in the condition of the poor, and so contributed to the general well-being of the community.

In 1835 the accurate record of births, marriages, and deaths commenced, and there began an era of trustworthy statistics, which, thanks to the indefatigable labours of William Farr, have contributed most

powerfully to extend our knowledge of the causes of disease, as well as of the laws which govern social progress.

In 1843 Mr. Edwin Chadwick, at the request of Sir James Graham, presented a special report on the practice of interment in towns, in which the evils of the plan were most carefully and exhaustively set forth, and from which rose the legislation of the subject that now directs a more reasonable and sanitary method of disposal of our dead. It is however to the writings and strong initiative of the celebrated Dr. Southwood Smith that we owe the real movement in the direction of civil sanitation, which has advanced with such rapid strides. So early as the year 1825 he was actively stirring up the question, and by his energy and influence interesting the minds of the public and the authorities in this all important matter. At length the appointment of the Health of Towns Commission, who issued their first report in 1844, brings us to the commencement of the really legislative stage of the present period in the history of sanitation. That commission, under the presidency of the Duke of Buccleuch, consisted of some of the most enlightened men of the time, among whom may be named Sir H. T. de la Beche, Lyon Playfair, Richard Owen, Robert Stephenson, Edwin Chadwick, and other honoured names, some now passed away, but others fortunately still left to see their good work bearing fruit, and to urge on and encourage by their experience and example the younger labourers in the same field. The commission issued a circular containing 62 questions, bearing on all the chief points affecting the

health of the community, and published the replies from fifty towns on sewerage, drainage, cleansing, and water supply. A number of witnesses were also examined, foremost among whom were Dr. Southwood Smith, Dr. Neil Arnott, Dr. Guy, Mr. Toynbee, Dr. Rigby, and others, and from them a large amount of valuable information was collected. It is extremely interesting to glance through and get an idea of the sanitary condition of the country at that time. Things are far from being perfection in the present day, but few who have not looked into the question have an idea of the Augean stable those men had to deal with.

Bradford, for instance, reports 'no drainage regulations; accumulations of refuse thrown from the houses; no arrangements for under-drainage; house drains emit offensive smells; no local regulations save the Highway Act; courts and alleys very offensive; inadequate supply of water, which is sold to the poor at three gallons for 1d.'

Bristol reports many houses without drains; bad water supply.

Bury, no regulations; stagnant open ditches in many places; drains frequently choked, very offensive; no regular scavengers; refuse carted in the street a sad nuisance; no local authority.

Carlisle, much the same condition; corporation refuse leave to open communications with water-closets in consequence of defective state of the sewers; refuse removed in wheelbarrows; water brought in by cart and hand from river.

Chester, equally bad.

Gateshead, utterly devoid of sanitary arrangements; house drains conveyed into the kennels of the streets; courts and alleys replete with the most offensive accumulations; water sold to the poor at a farthing for four gallons; others get it from springs, where they frequently wait one to three hours.

Gloucester, *Halifax*, *Hull*, *Kidderminster*, *Leicester*, all in similar condition.

Liverpool, drainage defective, full of pits of stagnant water; sewers neglected; refuse rots on the surface; the liquid matter is absorbed and finds its way into the cellars; house drains when they do exist, are not properly cleansed; local Act defective; water-closets not allowed to flow into the sewers; scavenging done by paupers. As a set-off the water is reported extremely good, but there are no public pumps or fountains; many of the poor beg and steal it.

Manchester, very much in the same condition.

Newcastle-on-Tyne, with every other unsanitary condition, confesses that its water supply is rendered impure from the drainage of the sewers.

North and South Shields, similar.

Norwich, in a generally unsanitary state.

Nottingham has the advantage of a good supply of water; otherwise in a bad condition.

Portsmouth, unsanitary in every particular.

Preston, *Rochdale*, *Sheffield*, *Salford*, *Sunderland* (which has however a good supply of water), *Wolverhampton*, all tell the same story.

When we come to examine some of the detailed

evidence we find an immense accumulation of causes of disease. Thus in the case of Liverpool the evidence of Dr. Duncan is taken. In the first place, as regards death-rate. Whilst in the metropolis generally only 1 in 37·38 died, in Liverpool 1 in 28·75 died. In the metropolis 111 per 1,000 died over the age of 70, in Liverpool only 54. In the metropolis 408 per 1,000 died under 5 years of age, in Liverpool 528. Again, the average age at death in the metropolis was 26½ years, whilst the average in Liverpool was only 17. The causes of this great mortality were not far to seek. More than *one-third* of the working population lived in *courts*, of which *one-third* were closed at both ends, less than *one-half* open at one end, and less than *one-fourth* open at both ends. As a general rule no house could possibly have any efficient ventilation, much less a thorough draught. More than 20,000 persons lived in *cellars*, of which there were about 7,000; these are described as follows:—'The cellars are ten to twelve feet square, generally flagged, but frequently having only the bare earth for a floor, and sometimes less than six feet in height; there is frequently no window, so that light and air can gain access to the cellar only by the door, the top of which is often not higher than the level of the street. In such cellars ventilation is out of the question. They are of course dark; and from the defective drainage they are also very generally damp. There is sometimes a back cellar, used as a sleeping apartment, deriving its scanty supply of light and air solely from the front apartment. About one-third are from five to six feet deep, five-sixths have no window

to the front, and forty-four per cent are reported as being either damp or wet.'

No arrangements existed for the disposal of the excreta of this population, whose solid excretions alone must have amounted to about 6,000 tons annually. Even when there were privies they were totally inadequate to the wants of the people, generally ruinous, always filthy; there being no drains, wells had to be dug to prevent the inhabitants being inundated, and one of these wells, four feet deep, filled with this stinking fluid, was found in one cellar under the bed where the family slept! Another cellar filled with similar abominations was used as a dairy where milk was kept! I may here mention that a similar state of things, even in the better class of houses, was pretty much the rule in many places. For instance, in the town of Southampton (which used to be a resort for invalids), before a drainage system was introduced, the usual place for the cesspool of one house was under the kitchen floor of the next; the result was severe endemics of typhoid fever, and I have been told by old and experienced practitioners there that when a suspicious case showed itself in a house in the older parts of the town, one of the first things they did was to have the kitchen floor taken up, with the frequent result of finding the neighbours' cesspool very conveniently located there.

Another key to the great mortality of Liverpool was the general crowding in the occupied area, the average density being nearly three times that of the metropolis, whilst one part showed a density more

than twice and a half as great even as that of the East and West London Unions, generally believed to be the most crowded in the kingdom. Liverpool has laboured under one great disadvantage, from its situation making it a chief point of debarkation for the Irish immigrant population, who, being generally very poor, are compelled to huddle together in wretched and crowded dwellings, and so become the foci of disease. Consequently, in the matter of fever, the deaths were considerably above other places, being one in 407 inhabitants, whilst the metropolis had only one in 690, and Birmingham one in 917. The deaths from consumption in Liverpool were one in 156, in the metropolis one in 246, in Birmingham one in 207. Deaths from convulsions and teething in Liverpool one in 188, in the metropolis one in 453, in Birmingham one in 645. The seeds of this disease, consumption, were doubtless sown in early childhood, not only in their unhealthy and crowded homes, but in the equally unwholesome schoolrooms in which some at least passed their time. From the report of Mr. Riddall Wood (about 1837) it seems that the condition of the schools was very bad. He says:—'The condition of most of the schools in an extensive and populous district is wretched in the extreme, corresponding in a remarkable manner with that of the population. With few exceptions, the dame schools are dark and confined; many are damp and dirty; more than one-half of them are used as dwelling, dormitory, and schoolroom, accommodating in many cases a family of seven or eight persons; above forty of them are cellars. Of

the common day schools in the poorer districts it is difficult to convey an adequate idea; so close and offensive is the atmosphere in many of them as to be intolerable to a person entering from the open air, more especially as the hour for quitting school approaches. The dimensions rarely exceed those of the dame schools, while frequently the number of scholars is more than double. Bad as this is, it is much aggravated by filth and offensive odour from other causes.' Mr. Wood states that the masters and mistresses were generally ignorant of the depressing and unhealthy effects of the atmosphere which surrounded them, and he mentions the case of the mistress of a dame school who replied, when he pointed out this to her, that 'the children thrived best in dirt!' He notices particularly a school in a garret up three pairs of dark, broken stairs, with forty children in the compass of ten feet by nine; and where, 'on a perch forming a triangle with the corner of the room sat a cock and two hens; under a stump bed immediately beneath was a dog-kennel in the occupation of three black terriers, whose barking, added to the noise of the children and the cackling of the fowls on the approach of a stranger was almost deafening. There was only one small window, at which sat the master, obstructing three-fourths of the light it was capable of admitting.' The state of the schools in Manchester was hardly quite so bad, but 'neither there nor in Liverpool was there a single common day or dame school where there was a playground, where the children could get the change necessary for young persons.' On the other hand, in

Birmingham, which has always been about the healthiest of our large towns, the schools were in much better order, generally on the ground-floor of the house, and not as in Liverpool and Manchester, frequently in garrets and cellars.

In investigating the causes of disease Dr. Duncan gives some instructive tables showing that deaths, both total and those from fever, were in the direct ratio of the crowding of the inhabited area; where this ratio was apparently departed from in any degree, the chief cause was traceable to the variable amount of *court* and *cellar* population. Although as a whole the sewerage of streets was a noticeable factor, yet it did not exercise so strong an influence on the fever ratio as the writer perhaps expected. This was apparently an anomalous fact at that time, but one which we can now understand, thanks to the differentiation of fever effected by Jenner. For although there would doubtless be a good deal of enteric fever, yet the principal diseases were most probably typhus and relapsing fever, due to crowding and destitution. Crowding, as a factor in enteric fever, operates only in an indirect manner, whilst it is a prime agent in the propagation of the others. This is especially seen in the account of one district of the town, where the space per inhabitant varied from four to ten square yards; showing in one instance a density of population equal to 658,000 per geographical square mile, or over 1,000 persons per acre. In one street of fifty-eight front houses fifty-one were without either privy or ashpit. Is it a wonder that ten per cent. and in one part four-

teen per cent. of the population was attacked with fever? To show that it is the interest, even from a selfish point of view, of all classes to promote sanitary improvements, a table is given extracted from Mr. Chadwick's sanitary report on England, where it is shown that the average age at death in Liverpool of all classes is seventeen years, against twenty-five in the metropolis, thirty-one at Bath, and thirty-six at Kendal. Even Manchester had one year more of life. Analysing the death-age of different classes, we find that, whilst London and Leeds gave forty-four years, Kendal forty-five, and Bath fifty-five, for the gentry and professional persons, Liverpool could only show thirty-five years as the expectation; for the tradesmen class, twenty-two against twenty-eight in the metropolis; and for the labouring population only fifteen years against twenty-two in the metropolis. It is but just to say that the municipality of the borough have been alive to the evils and have used endeavours to mitigate them. So early as 1802 they attempted to get an Act for the purpose, and sought the advice of the medical profession as to the points most necessary to be insisted upon. Unfortunately the enemy 'vested interests' stood in the path, and the opportunity was lost, at the sacrifice, Dr. Duncan calculates, of 40,000 lives. In speaking of an Act more auspiciously obtained in 1844, he says that, even could the death-rate of Liverpool be reduced to that of Birmingham, it would, with the then population of the town, effect a saving of 1,250 lives per annum.

Such a picture of past times cannot but be instruc-

tive, and I have selected Liverpool as an example, both because it is one of our most important cities and also because we have for comparison another report made more than a quarter of a century later, by two of the ablest physicians in the kingdom, viz.: Dr. Parkes and Dr. Burdon Sanderson. It was again at the request of the corporation that those gentlemen proceeded to Liverpool for the purpose of examining into the causes of the high death-rate existing at the time. Here we have clear proof of the imperfection of existing legislation. While much has been done in the way of sewerage,[1] paving, provision of trough water-closets, removal of middens, &c., yet the habits of the populace continue so filthy, and they are so drunken and improvident in many cases, that much of the good effected by the authorities is completely neutralised. The death-rate of children under five years of age still remains exceptionally high in the poorer districts, and the general death-rate continues very large. Nothing (as Drs. Parkes and Sanderson remark) will effect any real good, except complete demolition of those nests of disease and the scattering of their population. In this way legislation will effect much good, for it is hopeless to expect that anything like moral elevation, the only real guarantee for permanent improvement, can be accomplished in such noisome dens, where even the rudest forms of decency are not only neglected, but never have even a chance of being attended to. It has been most truly said that a comfortable home, implying the

[1] The 'Report' says Liverpool is *well* provided with sewers, some of which have been constructed at very great cost.

possibilities of being moderately cleanly in habits and decently moral in conduct, will do more to effect sobriety and moral improvement than all the Permissive Bills and Temperance Unions that ever existed. The report gives some graphic and really appalling sketches of the vice and misery in Liverpool, showing how by mere proximity the best-intentioned are corrupted.[1] 'With regard to the cleanliness of these houses, it was clear that a good deal had been done lately in several houses by lime-washing the walls, and by compelling the people to clean the houses. The epidemic of relapsing fever had probably led to this. But, in spite of this enforced cleaning, nothing could exceed the dirt of the people and the fœtid condition of the atmosphere at night. How human beings could tolerate such a state of things would be incredible, if we did not know the deadening influence of custom. The peculiar construction of the houses and the entire want of ventilation intensify the effects of this universal uncleanliness. For it is almost impossible also, sublet as the rooms are in most of these houses, for the people in one room to be clean while the others are dirty. They give up the attempt in despair.' In a note it is also stated that the Health Act itself has operated unfavourably by rendering it almost impossible for owners to interfere with the tenants, for the latter go to the health officer and lodge a complaint; the owner receives an order to clean the houses, the expense of which is so great that he prefers to leave them alone. Thus the habits of the

[1] 'Liverpool Report,' p. 64.

people are dirtier now than before 1847. There is surely something wrong somewhere. Altogether we may gather from the history of Liverpool how comparatively powerless legislative interference is when opposed by the counter forces of drunkenness, personal filth, and moral degradation; and that to deal with a community of such a size and so enormously increasing a population requires measures of a magnitude which may well appal the average mind of a town-councillor or vestryman.

There is another point which strongly impresses me in considering such a picture of misery and degradation, and that is, that one of the most important moves that could be made for the benefit of the people would be a means of cheap transport from one place to another. Were it possible to move bodies of labourers from one place to another, as work presented itself, it would tend enormously to lessen many of the evils I have mentioned; and would, I firmly believe, go a long way to extinguish pauperism in the land. It would also enable the population to scatter more widely around great centres and obviate the dreadful huddling together which is productive of so much evil. Much has been done of late years in this direction by the establishment of workmen's trains, but the principle requires to be vastly extended, and some such plan adopted as that proposed a few years ago by Mr. Raphael Brandon, viz., a uniform fare for any distance in one journey throughout the kingdom. He proposed 1s. first, 6d. second, and 3d. third class—sums that sound at first hearing ridiculous, but not one whit more so than the penny post did when first proposed. When it is known

that the average fare paid by each traveller for each railway journey in the kingdom is something under one shilling and twopence, the feasibility of the scheme becomes more apparent. Of course it would entail the government taking over all the railways, but that might be done without costing the country a sixpence. Without going into details that would be at present out of place, I may express my conviction that such a system might be worked at an enormous profit to the state, and to the still greater benefit of the community. No doubt the public mind will have to be educated up to so great an idea, but when the time is ripe it will only remain for some real statesman of comprehensive views to carry out this plan, which would not only soon be followed by other countries, but would ultimately lead to an international locomotion, just as we are now beginning to establish an international postage. It is one of the mightiest agencies in store for future generations; it will break down the barriers of ignorance and prejudice which now separate one nation from another; it will sweep away superstitions; it will deal staggering and even fatal blows at all oppressions, secular or ecclesiastical; and in the best and happiest sense change the face of the world.

Salisbury.—To take another town, of a totally different character from Liverpool, let us select Salisbury. Capt. (afterwards Sir W.) Denison, R.E. reports it, in 1842, in a very unhealthy condition, for, taking even a favourable year, the death-rate was 26 per 1,000, chiefly due to scarlet fever and typhus, by which latter enteric fever was probably really indicated. The situation

of the city is unfavourable, lying in a hollow on the bed of the Avon, and surrounded with water-meadows. The consequence was that in the frequent floods that took place the drains were choked and sewer gases driven back into the house. Again, the road trustees had powers over the main thoroughfares, but had no power to enforce the cleansing of the numerous courts where the populace lived, and in which there were terrible accumulations of filth. With regard to the remedies proposed, Capt. Denison is 'afraid that any attempt to improve the general drainage, so as to cause the water to pass off with greater rapidity, would be found impracticable; it would interfere with too many interests, and after all be of doubtful value.' As a matter of fact Salisbury since that time has been thoroughly drained, with the gratifying result of lowering the death-rate from every cause and converting it into one of the most healthy places in the kingdom.[1] (See the 'Report of Dr. Buchanan'—Privy Council Reports.)

Among other reports of great interest is one by the Rev. J. Clay on the condition of Preston, in Lancashire. This contains a great deal of interesting information bearing upon the relative death-rate and vitality in proportion to age, occupation, and amount of population. I cannot do more than briefly notice a few of these points. With reference to the influence of increasing death-rate from increasing population, we have the table at p. 176 of the report. Separating the deaths into districts we have the notable result that in the

[1] *E.g.* the death-rate shows (1872) the proportion under five years to be 330; all England, 401.

well-conditioned streets there is a percentage of deaths under five years of age to total, of 35 (or 350 per 1,000); in the moderately-conditioned streets, 520 per 1000; in the ill-conditioned, 705 per 1,000, and in a particularly bad section, 738 per 1,000. That the town was not itself naturally unhealthy was shown by the mortality in the jail, where in five years there was only 1 death to 547 inhabitants, or a ratio of 1·83 per 1,000, whilst the most healthy districts show at the best ages at least 7 per 1,000.

This is a point that demands attention for a moment. The prison in question was the house of correction, and the daily average number of prisoners was 219, of whom one-sixth were females — not counting infants, who do not appear on the books, and who numbered about six as an average. The average age was 28·9 years. During five years only two deaths occurred, one from a casualty and one an aged female, who was in a dying state when she was brought in. The mortality in the town was seventeen times as great as in the prison. Even in Liverpool the death-rate among prisoners at the same period was one in seventy, or about fourteen per thousand, less than one-half of that in the town itself. And the same thing has been noticed elsewhere, even in India, where the circumstances are so much less favourable. Now if it be possible, by rigid hygienic measures, to produce such a standard of health among a class so degraded and so little accustomed to self-control, what might not be done among an intelligent and well-instructed

The main cause of the great mortality has been the increase of the population to a very rapid extent, with proportionate crowding and inattention to all sanitary arrangements. This is shown by Table I., which gives the population at about ten-year intervals from 1783 to 1841, with the average age at death, and the percentages of total deaths occurring under and over five years of age. The curves are very remarkable, and the only apparent discrepancy is in the year 1831, which can be accounted for from the circumstance of its being a cholera year, in which more adults die, and the consequent age at death becomes increased, with a proportionate diminution of the percentage of early deaths. The chief element (which I propose to call epithanatic [ἐπιθάνατος, morti obnoxius]) is of course the lower class, or operatives; in the early part of its recent history this formed a very small part of the population of Preston, there being only one small factory, built in 1777, and only after 1791 additional ones put up. But from 1797 the increase has been enormous, with the result, at the time of Mr. Clay's report, of a general deterioration of vitality. Table II. shows the streams of life at Preston among the three chief classes, the gentry, tradesmen, and operatives; here we see the enormous loss of infant population in the operative class, a considerable loss among the tradesmen, and a much smaller loss among the gentry. The next cause of death is to be sought for in the general filth of the place. Here, for instance, is a description of Back Queen Street:—' A visitor, on entering it, finds himself facing a row of privies

Table 1

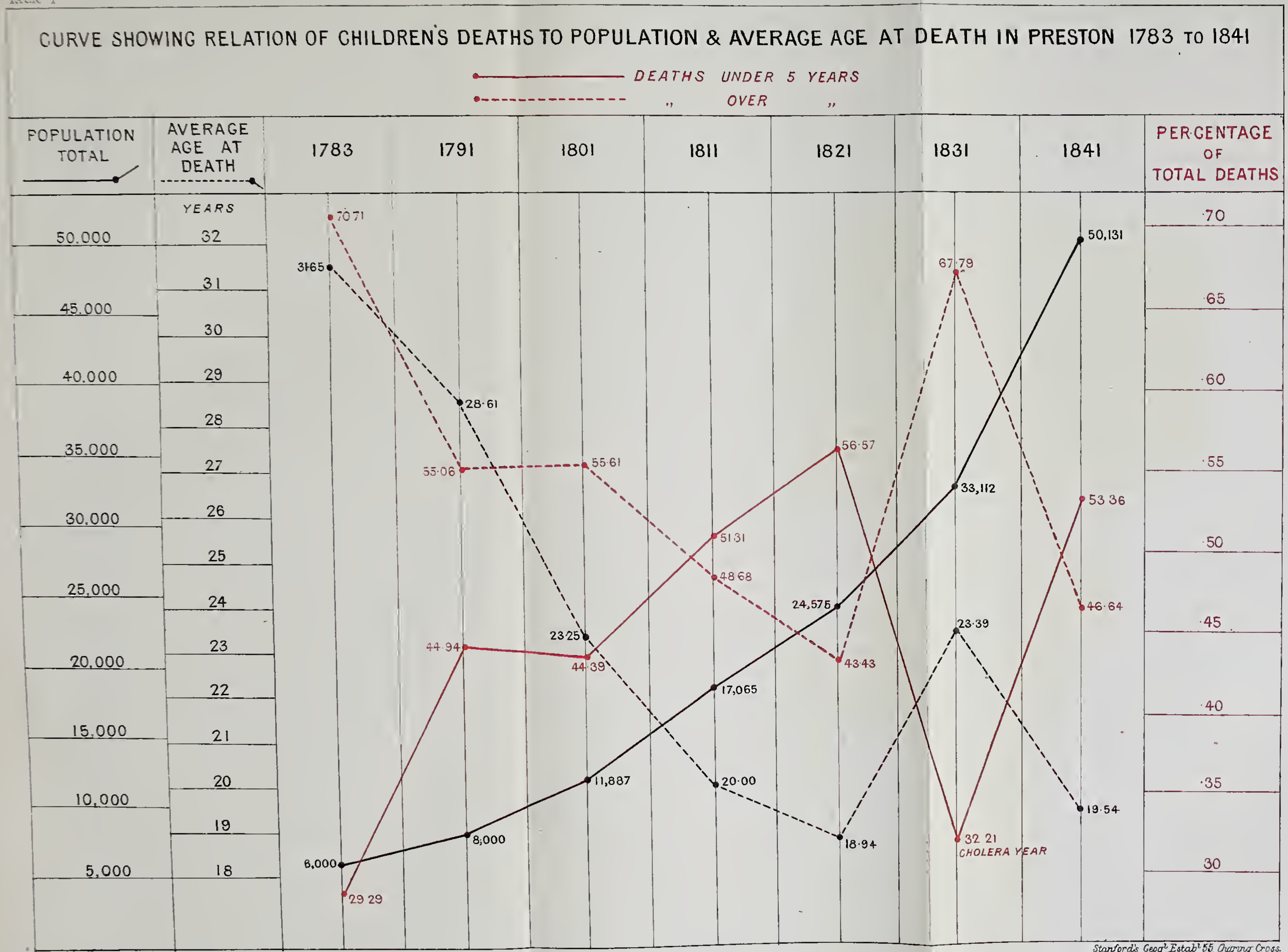
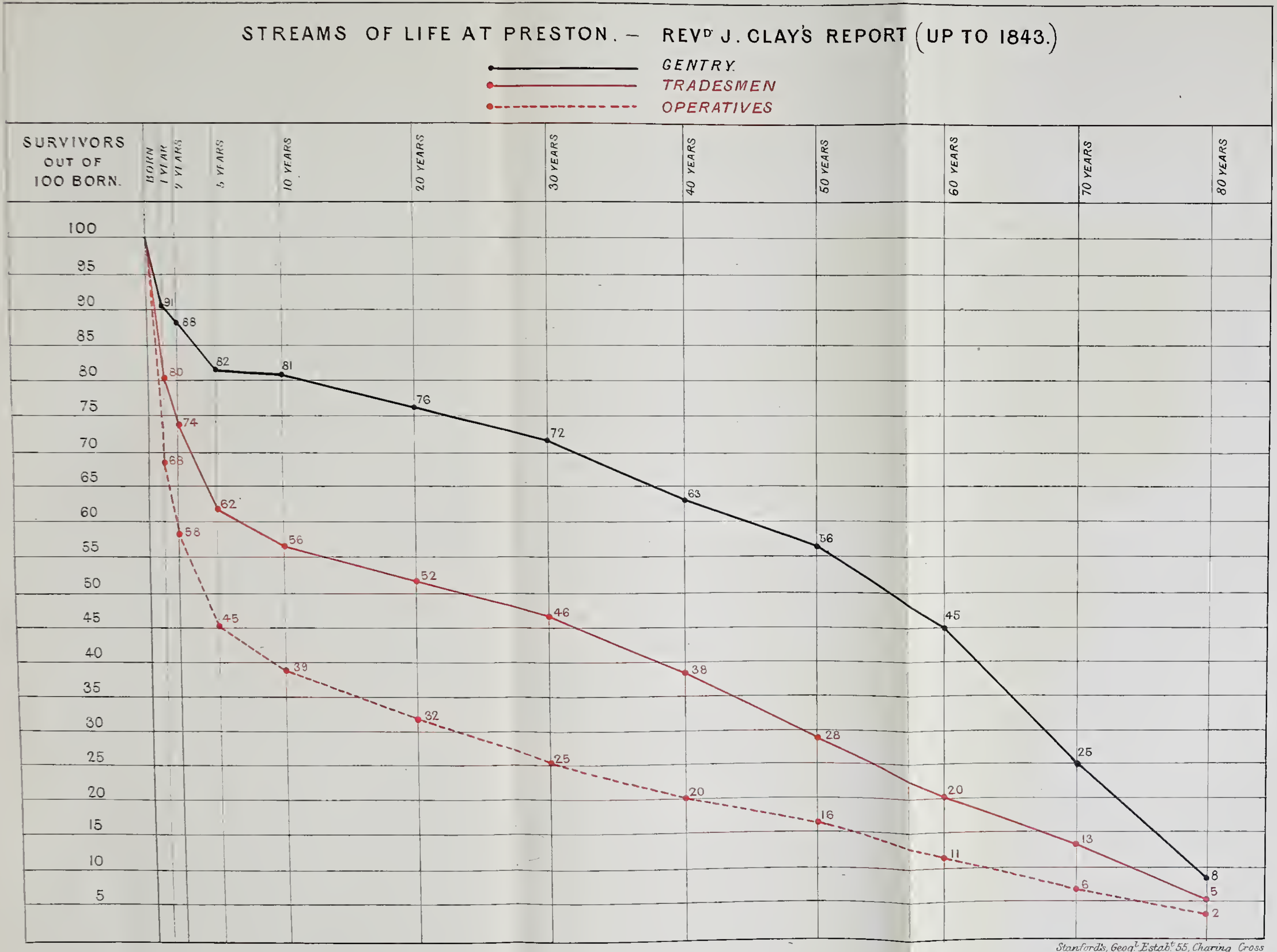
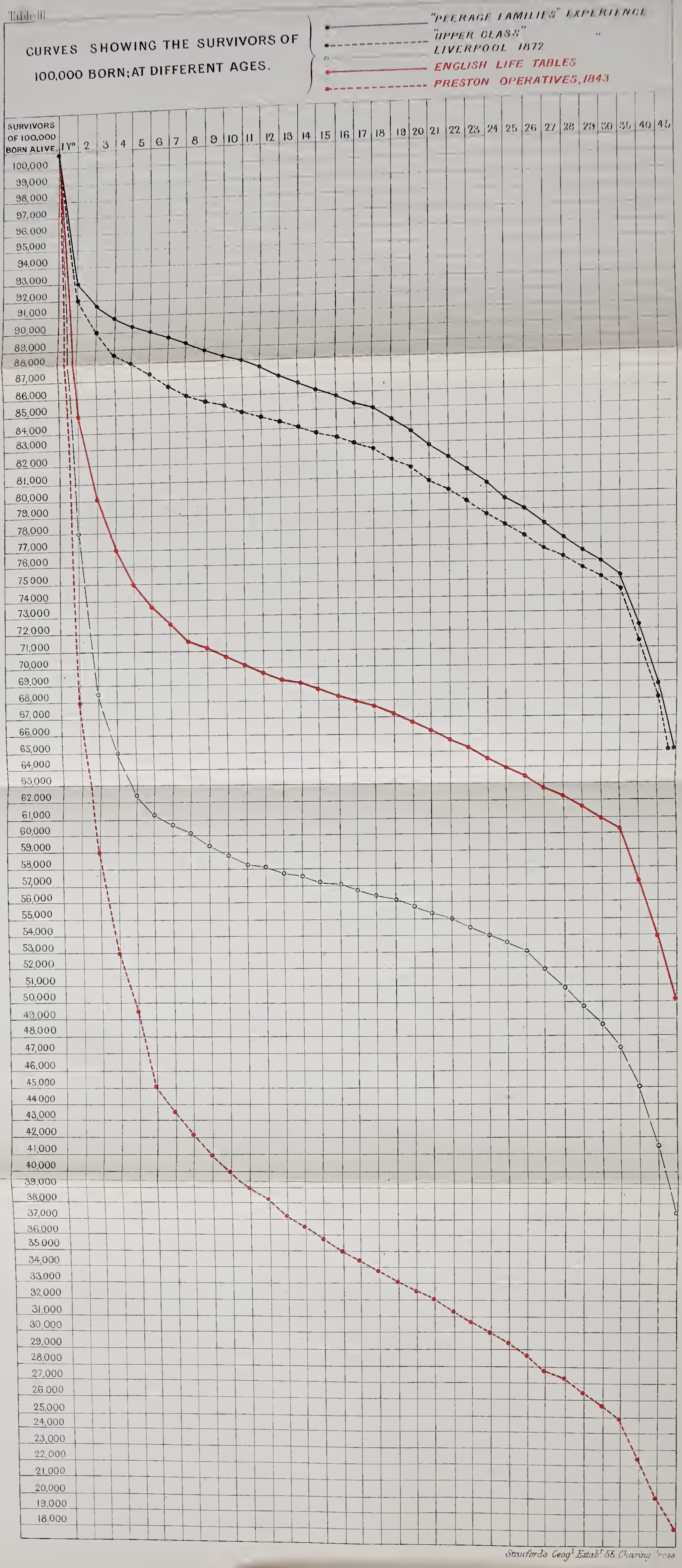

CURVE SHOWING RELATION OF CHILDREN'S DEATHS TO POPULATION & AVERAGE AGE AT DEATH IN PRESTON 1783 TO 1841
DEATHS UNDER 5 YEARS
" OVER "
POPULATION TOTAL
AVERAGE AGE AT DEATH
YEARS
1783
1791
1801
1811
1821
1831
1841
PERCENTAGE OF TOTAL DEATHS
50,000
45,000
40,000
35,000
30,000
25,000
20,000
15,000
10,000
5,000
32
31
30
29
28
27
26
25
24
23
22
21
20
19
18
·70
·65
·60
·55
·50
·45
·40
·35
30
70·71
31·65
28·61
55·06
55·61
56·57
67·79
50,131
33,112
53·36
51·31
48·68
24,576
46·64
23·39
44·94
23·25
44·39
43·43
17,065
11,887
20·00
19·54
8,000
32·21
CHOLERA YEAR
6,000
18·94
29·29
Stanford's Geog! Estab! 55, Charing Cross.

Table II.



STREAMS OF LIFE AT PRESTON. — REVD J. CLAY'S REPORT (UP TO 1843.)
GENTRY.
TRADESMEN
OPERATIVES
SURVIVORS OUT OF 100 BORN.
BORN
1 YEAR
2 YEARS
5 YEARS
10 YEARS
20 YEARS
30 YEARS
40 YEARS
50 YEARS
60 YEARS
70 YEARS
80 YEARS
100
95
90
85
80
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5
91
88
82
81
76
72
63
56
45
25
8
80
74
62
56
52
46
38
28
20
13
5
68
58
45
39
32
25
20
16
11
6
2
Stanford's, Geogl. Estabt. 55, Charing Cross

Table III


CURVES SHOWING THE SURVIVORS OF 100,000 BORN; AT DIFFERENT AGES.
"PEERAGE FAMILIES" EXPERIENCE
"UPPER CLASS" "
LIVERPOOL 1872
ENGLISH LIFE TABLES
PRESTON OPERATIVES, 1843
SURVIVORS OF 100,000 BORN ALIVE.
1 Yr 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 35 40 45
100,000
99,000
98,000
97,000
96,000
95,000
94,000
93,000
92,000
91,000
90,000
89,000
88,000
87,000
86,000
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36,000
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33,000
32,000
31,000
30,000
29,000
28,000
27,000
26,000
25,000
24,000
23,000
22,000
21,000
20,000
19,000
18,000
Stanfords Geog^l Estab^t 55, Charing Cross

more than one hundred yards long. The doors of the privies are about six feet from the house doors opposite, and the space between one privy and another is filled up with all imaginable and inimaginable filth; so that the street consists of a passage little more than six feet wide, with dwellings on one side, and a continuous range of necessaries, pigsties, middens, heaps of ashes, &c., &c., on the other, with a filthy and sluggish surface drain running along one side. The doors opening into this street are in some cases the back doors of the Queen Street houses; but twelve houses have their only outlets—doors and windows—upon this disgusting and pestiferous passage.' The death-rate in this pleasing district was, for the year 1841, sixty-nine per thousand! Another cause existed in the singular apathy of the populace, due to ignorance or habit, or both. A case is cited to the point. 'A night watchman at one of the principal mills, having met with a serious accident, was taken home and there visited by the medical gentleman who furnished this account. The sufferer's home or lodging was approached by a passage three feet two inches wide, and the lodging itself consisted of a low room, six feet nine and a half inches long, and four feet eight and a half inches wide, lighted by a pane of glass in the roof nine inches square. The small bed, which almost filled this wretched room, was occupied alternately by the watchman and an old man labouring under paralysis—the latter quitting the bed when the watchman returned from his nightly duties, and entering it again when vacated in the evening. The watchman was a

single man, sober, and orderly in his conduct, and receiving regular wages of eighteen shillings a week, a sum which would have enabled him to procure good lodgings, and every attendant comfort.' Another case: 'A shoemaker, who, with his wife, could earn twenty-five shillings weekly, keeps a pig in the room in which he, his wife, and three children live. A sow, belonging to a friend, having brought forth a more numerous litter than she could support, the shoemaker fitted up, for the reception of the two supernumerary pigs, a corner of his living room, in which they were found by the agent of the charitable society.' In addition to those causes already cited remain, of course, insufficient or improper food, drunkenness of parents, the giving gin to the infants, and the general use of Godfrey, Daffy, and other nostrums, which prove only too surely passports to another world.

These are only a few notes of the remarkable reports collected by the Health of Towns Commission, reports which would of themselves furnish material for many lectures. To go further into them would, however, take up more time than could properly be allotted to them in the present instance, but we may safely say that this report was one of the most important steps of the great move of sanitary improvement of which we are only now in the present day beginning to see the outcome. Following close upon it came the enquiry by the Metropolitan Sanitary Commission, in 1847, which collected a large amount of most important information. This was instituted in anticipation of the probable advent of cholera, which

made its appearance in 1848 and 1849, and the members of it were Lord Robert Grosvenor, afterwards Lord Ebury, chairman, Mr. Edwin Chadwick, Dr. T. Southwood Smith, Mr. Richard Owen, and Mr. R. L. Jones. They reported on the grounds for apprehending a visitation of cholera, the circumstances under which the disease is favoured, its relation to typhus and other epidemics in its propagation and distribution, the sanitary condition of the different districts of the metropolis, and the principles and means of drainage, as being one of the most urgent questions under the existing circumstances. Evidence was collected from about thirty-five witnesses, and the results showed that cholera in its previous visit attacked the same places where fever was at other times prevalent; that it spread most in the most crowded places with the largest pauper population; that the existing methods of removing refuse were most incomplete; that the drains generally were badly arranged and badly constructed, and that there was the greatest difficulty in getting house drainage accomplished at all, on account of the expense, the opposition or apathy of neighbours, the supineness of boards, and the want of legislative power to enforce necessary improvements. The evidence of Sir George Phillips, M.P., for instance, shows the obstacles he had to encounter to get drainage for his stables, although he offered to bear a considerable portion of the expense himself; he found that he must either revert to cesspools that had already become an intolerable nuisance, or else drain at his own expense for the whole neighbourhood. Taking a

district of Bethnal Green as a sample of the condition of the poorer districts, we find that the district is without water, because the water company and the landlord have quarrelled; it is almost undrained, because the chairman of the commission of sewers is of opinion that the office of the commission is not to make sewers, but to keep in repair those already made; private houses generally do not communicate with the sewers that do exist. Here is a description of a little paradise, which (save the mark!) is called Jubilee Place: 'It consists of eight houses, having no back premises; there are two privies in the open yard in front of the houses common to them; there is but one stand-pipe, from which water is obtained three times a week. The houses Nos. 3 and 4 have a drain passing under the floor; they stink most abominably, and the paint (white lead) is blackened by its conversion into sulphuret of lead. This court is approached by a very narrow alley, and has no ventilation; it is a stagnant lake of air loaded with putridity.' In this street, in a room of less than 640 cubic feet nine persons slept: or 70 cubic feet per head of air-space; in Little Collingwood Street, ten persons had less than 600 cubic feet, or under 60 cubic feet per head of air-space; in Foster Street one room gave 63 cubic feet per head; and in Elizabeth Place one gave 80 cubic feet. Such places, to be even partially ventilated, would require the air to be changed ten times an hour—to be well ventilated, at least *once every minute*, a manifest impossibility.

Without delaying longer on this report, I may

briefly mention that following upon this and other sources of information came the Public Health Act of 11 and 12 Victoria, which established the General Board of Health, the work of which is inseparably connected with the name of Edwin Chadwick. That body was empowered to make a series of enquiries into the health of districts on application from the inhabitants, and to direct in appropriate cases the application of the provisions of the Act. The mass of information collected by the Board during its term of existence forms a treasure of facts bearing upon the condition of communities which has been as yet but little utilised, but must unquestionably be considered as among the most valuable contributions to the history of sanitation. A glance at one or two enables us to see the change occurring in the course of years, and, accordingly, turning to the reports on Preston and Salisbury by Messrs. G. T. Clark and T. W. Rammell, we find points of comparison with the results of earlier enquiries already noted. Taking Preston in the first instance, as the more important town of the two, we find that in 1849 comparatively little improvement had occurred since Mr. Clay's report, the few bright spots in its history being its naturally healthy site and its excellent and constant supply of good water, although not supplied direct to all houses. But the same filthy streets, the same deposits of unimaginable horrors, the same crowded graveyards, remained as before, and the reporting inspector calls for the immediate application of the Public Health Act. The death-rate was then 29·94 per thousand; in 1868 it

was 33·5 (population 83,000); in 1872 it had fallen to 26·7 (population nearly 86,000).

Glancing at the condition of Salisbury, in 1851 we find the population diminishing, the value of property decreasing, and the health of the inhabitants bad, as it had always been from the time when Peter de Blois first proposed the move from the high, airy, but bleak and lonely hill of Old Sarum to the present low-lying swampy site. The prevalent diseases from 1844 to 1850 were phthisis and other lung diseases; Asiatic cholera (in 1849), diarrhœa, measles, whooping-cough, scarlatina and small-pox, teething and convulsions, tabes, typhus—in short, the diseases most favoured by crowding, bad air, and sewer emanations. The death-rate showed a mean of 31·5 per thousand, reaching 28·5 in a non-choleraic year, and 50 in 1849, the year of cholera, falling to 18·6 in 1850, no doubt from the large number of epithanatic individuals removed the previous year. The drainage was bad, being chiefly accomplished by open watercourses, which were very offensive, whilst the city lies so low that the ground was continually damp, so much so that the ground had to be actually raised in many cases to prevent the houses being overflowed; even now, many of the best houses in the place are entered by a *descent* of several steps.[1] In former times the town was frequently visited by the plague; in 1604, 1,152 persons died of it—probably 10 to 12 per cent. of the population; in 1849 the cholera carried off one-

[1] Town built in chequers, the interiors of which are filthy, and the air in them stagnant.

fortieth of the inhabitants. Burton, in his 'Anatomy of Melancholy,' refers to the bad air of the place as tending to 'engender melancholy plagues and what not.' As I have before mentioned, much improvement has taken place in later years, by the abolition of the watercourses and a thorough draining and drying of the subsoil. Accordingly, we find that in 1868 the death-rate was only 17·4, against 24 from 1851 to 1860, the deaths from phthisis being only 2; whilst the mean for the seven years, 1844 to 1850, was $4\frac{1}{2}$. In 1872 the death-rate had risen again considerably, but this was partly due to an excess of scarlet fever, although an increase in phthisis had also taken place.

A report made in 1849 by Mr. Rawlinson gives an appalling account of the town of Whitehaven in a tabular form; the tenements are described as filthy, not one in a hundred ventilated; a large number mere cellars; no privies in many cases; no water supply; beds mere rags and straw; and furniture almost *nil.*

One of the most important provisions in the Public Health Act was the granting of powers to make sanitary improvements and spread the expense over a number of years. This removed one of the most serious obstacles to sanitation, namely, the great immediate expense which was a positive bar in many cases, and in still more only too excellent an excuse for delay and inaction. There was power, however, given in this Act for the establishment of Local Boards of Health, under certain limitations, who should carry out the necessary sanitary arrangements, paying for the

same by a special rate, spreading over a period not exceeding thirty years; the rates might also be mortgaged with the consent of the General Board.

The Common Lodging-Houses Act and the Labouring Classes Lodging-Houses Act were passed in 1851–2, and were measures of great importance in a sanitary point of view.

The Metropolis Local Management Act, so important in the matter of the drainage of London, was passed in 1855, the metropolis having been omitted from the provisions of the Public Health Act of 1848. Some other minor acts of consolidation were also passed about this time.

In 1858 the career of the General Board of Health came to an end, and its powers were transferred by enactment to the Privy Council. Although the General Board of Health was avowedly a provisional body, and although some of its doings have been much criticised, it is impossible not to recognise the great value of the work done under its auspices, and the powerful impetus given by it to sanitary improvement.

With the period of Privy Council superintendence of the public health are connected the names of Simon and his able staff, Buchanan, Netten Radcliffe, Thorne, Ballard, Seaton, &c., names familiar to all in the recent history of sanitary progress.

At the same time that the powers of the old Board of Health were transferred, another Act was passed, called the Local Government Act, which consolidated in an improved form and extended the provisions of previous laws. Various Acts were passed subsequently,

amending, extending, or otherwise altering the provisions of the different Acts already in existence.

In 1860 (August 6) the Adulteration of Food and Drink Act was passed, forming an important step in advance on a subject which is still exercising the minds of the legislature.

Among the Acts passed, one set of great importance has been the subject of much controversy, namely, the Contagious Diseases Prevention Acts, commonly known as the C. D. Acts. Considering the amount of prejudice existing in this country on the question, it is a matter of astonishment to me that those Acts were ever passed; but it is, at the same time, a happy thing in my opinion for the country that they were so passed, and it will, I think, be a misfortune if they are repealed. I shall probably have occasion to refer to them at another time, and so shall leave aside any more detailed consideration of them for the present.

In the session 1871–2, the Local Government Board Act was passed, vesting in one central Board the powers previously exercised by the Poor-Law Board and the central Sanitary Authority; and in the following session the Public Health Act was passed, authorising the appointment of officers of health, and the Adulteration of Food Act, authorising the appointment of public analysts on a more extended basis than formerly.

The present session has seen three new Bills introduced, namely, a Public Health Bill, chiefly intended to consolidate previously existing Acts; an amended Adulteration Bill; and the Artisans' and

Labourers' Dwellings Bill. It would be probably premature at present to discuss the provisions of those Bills while they are still under the consideration of the legislature; but I may briefly glance at the objections raised to two of them. The Public Health Bill is objected to on the ground that sanitary legislation has hitherto been very imperfect, due to difficulties of various kinds, but partly also to the imperfections of sanitary science itself, and that consequently consolidation is as yet unadvisable. This objection is chiefly raised, I believe, from the fear that consolidation may come in this case to be considered equivalent to finality, and that the policy hereafter will be 'Rest and be thankful.' Were such a thing contemplated, I should certainly join in the opposition to the Bill; but I cannot think that consolidation alone, if well and honestly carried out, can be anything but a boon to everybody (except, perhaps, the lawyers). It is only a pity that all our laws cannot be consolidated, and codified in the fashion of the Code Napoleon, so that it might be possible for any ordinarily intelligent individual to know whether he is likely to break the law or not in any particular case. At present every one is supposed in theory to know the law—in sober fact there is no man in the kingdom, from the Lord Chief Justice downwards, who knows the law, or who is not liable to err against it, through sheer ignorance.

The Adulteration Bill has been objected to as not rendering its provisions sufficiently easy of application, and even putting obstructions in the way of previous

legislation on the subject. These, however, are points of detail which need not detain us now. However imperfect such legislation may be, we have made this great advance, that the health of the people under every aspect is now fully recognised to be a part of the business of the state itself. I remember the late ~~Lord Herbert of Lea~~ (then Mr. Sidney Herbert), in an address at Chatham on the opening of the Army Medical School, making these remarks :—'The position of the army medical officer, too, differs from that of his brother in civil life, especially in this, that the attention of the latter is for the most part taken up in curing disease, while he has very little opportunity of preventing it. Indeed, it seems almost against his interest to prevent disease. It is only the sick person who sends for the doctor, not the man who is well; and, with the exception of the navy and army medical officer, it may perhaps be said that there are no medical men who could gain a livelihood not by curing but by preventing sickness.' That was in 1860, and now we have, in 1875, the spectacle of hundreds of educated gentlemen, who, as officers of health or public analysts, are profitably devoting the whole of their time to that very duty which fifteen years ago his lordship thought so unpromising a branch of our art. Perhaps no one point could be cited that more markedly differentiates the present from the past, or brings more strongly home to us the advance that the science of public health has made in the estimation of the country.

I have briefly sketched the progress of legislation

on questions of public health as far as the sanitary requirements of civil communities are concerned; but a history of sanitation would be incomplete anywhere, but especially in this country, if I omitted to refer to the influence exercised by the army and navy. In the state's dealings with those large and important bodies of men some most important problems were worked out, and it is unquestionably in that direction that we must look for some of the valuable starting-points of public sanitation. The value of a life on board ship or in a campaign is so much more sharply perceived, that it was but natural that the means of preserving it should have first suggested themselves to the army and navy medical officers. Unfortunately, however, although much good was effected, their cry went up year after year too often unheeded. Peace came round, and poor Billy Taylor and Tommy Atkins were quickly forgotten, until a new war broke out, and the half of our forces perished in the early part of it, in expiation of the shortcomings of our rulers. The first campaign in Holland, Walcheren, and the Peninsula all told the same story; our tropical colonies and our Mediterranean stations sent hecatombs of souls to Hades; even our barracks at home were killing off men at twice the rate that their civil brethren died. In the meantime, stout old admirals and generals expressed their opinion that the men were being coddled, and the services going to the dogs. I remember a conversation in a railway carriage between two very old officers, one naval and the other military, on this question; after warmly abusing

Armstrong guns, Enfield rifles, and arms of precision generally, one of them remarked, 'What's that place they've got now down Southampton Water? Hospital, eh? doosid deal too much of that sort of thing going on now. We had no such hospitals in the Peninsular days, and we got on very well. Men did their duty and licked the French, and what more do you want?' Such men are almost fossils now, but they are instructive as showing the rugged road we have left behind. The Crimean War, which must be looked upon in many ways as a turning-point in modern history, was emphatically so in a sanitary sense. The 'horrible and heartrending condition' of our army, of which I can speak from experience, having passed the terrible winter of 1854 and 1855 in the hospitals at Scutari, roused and excited the public mind; and, after several partial enquiries were made, the Royal Commission on the health of the army sat in 1857. Their report is still of the greatest value in many respects, and it brought before the public a condition of things that was hardly dreamt of. Close upon this followed the Barrack and Hospital Commission, which gave a great impetus to scientific ventilation. Soon after this the Royal Commission on the health of the army in India assembled, immediately after our death-struggle in the great mutiny. The practical application of the recommendation of these commissions has so fully demonstrated the possibility of diminishing the sickness and mortality and preserving the health and energy of considerable bodies of men, that we may confidently hope that the evil days of our armies and navies are ended, the

best proof of which is the fact that in China in 1860, in Abyssinia in 1868, and in the Gold Coast in 1873, we have waged three small but most arduous wars, with a sanitary success wholly unparalleled in the long history of armies. From these facts we may also gather encouragement for the further success of sanitation in civil life, where there are of course many difficulties unknown to soldier or sailor, but also many helps which are alike foreign to both.

It was in 1860, on the foundation of the Army Medical School, that the first chair of sanitary science was created in this country, then as now filled by my distinguished friend and colleague, Professor Parkes, whose work on hygiene may be looked upon as the classic one in this country. I think I shall not be asking too much when I put in a claim on the part of the Army Medical School to a considerable share in the good cause of promoting sanitary progress. Other chairs of hygiene have been created and filled by worthy occupants in many places, while degrees and diplomas in public health or in state medicine are being instituted in the most important schools and colleges. In this way a continuous stream of highly-qualified sanitarians will be provided, who will be competent advisers of our public bodies and central authorities, until, at last, in some good time coming, vestries, guardians, corporations, and statesmen may realize the truth of the old adage,

Salus Populi suprema Lex.

LECTURE II.

AIR—ITS COMPOSITION, AND THE CHANGES IT UNDERGOES—EFFECTS OF IMPURE AIR—AIR SUPPLY AND VENTILATION—LEGISLATIVE ENACTMENTS EXISTING OR DESIRABLE.

Having in the previous lecture given a brief sketch of the history and progress of sanitation, I propose to commence in the present the consideration of the various branches of hygiene, and to take up specially the subject of air. We might divide the subject into general and special hygiene, including under the former the consideration of the surroundings of the individual, and his relation to the community; and under the latter those special points which bear more particularly upon his own personal hygienic management. It is obvious, however, that such a division could not be made complete, and that however carefully the subject were treated there would be some overlapping. It will be better therefore to avoid the temptation to too philosophical divisions, and merely consider the different points in certain plain and obvious sections, in which we can include the matters bearing upon the question, so far as time at least permits. As the divisions are printed in the syllabus, I need hardly detain you by reading them over.

It is plain that we have before us a very large field, over only a portion of which we can possibly travel in a limited course of lectures. I will try, however, to touch upon a few of the most interesting points, and refer to the part the state can most profitably play in exercising a controlling power.

For to-day's lecture, then, I select the subject of air and ventilation.

The common simile 'free as air' expresses a condition of air, by implication, as it ought to be, and as it is everywhere, except in our habitations, where it is so unfortunately 'cabined, cribbed, confined,' that it becomes a source of danger to life in place of being its prime necessity. There are several reasons for taking up this subject first, and one of the chief is, that it is the most constant and general agent in the production of disease and death. We may abstain for a time from food if we have reason to believe that its condition is objectionable; we may, for a shorter time, and at the cost of greater suffering, abstain from drink of any kind, if we have reason to apprehend danger in that direction; but we are bound to breathe the air as we find it, under pain of death itself. If, therefore, we find a community, living under pretty similar circumstances, and suffering from a general deterioration of health and constantly high death-rate, we may safely attribute the condition to the bad state of the atmosphere breathed. On the other hand, a sudden outbreak of disease is more likely to be attributable to the condition of the water supply; whilst, powerful as are the influences of bad

and insufficient food and excesses in stimulants, they must be looked upon as only secondary to the other prime factors already mentioned.

In considering the effects of bad air, it may be well to look first to the composition of normal air, and then consider the changes which it undergoes either in the quantity of its normal constituents, or by the introduction of extraneous substances. Air taken under the most favourable circumstances, in free open spaces or on elevated ground, consists of the following constituents (Angus Smith):—

Oxygen . .	209 to 211 parts; 209·6 mean.	
Nitrogen .	789 to 791 ,,	
Carbonic acid .	0·400 ,,	{ 0·200 / 0·500 }
Ozone . .	Variable.	
Vapour . .	Varying with temperature.	
Organic matter } Ammonia }	Very minute traces.	
Suspended matter	Variable.	

Looking over the numerous analyses in Dr. Angus Smith's work on 'Air and Rain,' as well as those given in the writings of others, the first thing that strikes one is the remarkable uniformity of composition that the atmosphere shows in different parts of the globe. Even in the neighbourhood of habitations and in the streets of densely-populated towns, there is much less variation than we should be inclined to expect—the law of diffusion and the effects of wind being such as to cause a sudden and rapid dispersion of the products

of combustion and respiration, so that, wherever nature is not obstructed by the ignorance and stupidity of man, she effects the fullest and completest ventilation. Thus, in Manchester, the following data are given by Dr. Angus Smith :—

	Oxygen. Per cent.		CO_2. Per 1,000 vols.
In fog and frost	20·9100	Streets . .	0·403
Outer circle, not raining	20·9407	Where fields begin .	0·369
Suburb, in wet weather	20·9800 20·9600	Streets in fog. . .	0·679

Again, in London we find :—

	Oxygen.		CO_2.
Open places, summer	20·9500	On Thames .	0·343
Streets, Nov. .	20·8850	Parks, open .	0·301
		Streets . .	0.380

Now I reckon that, at the lowest estimate, there cannot be less than 300,000,000,000 cubic feet of carbonic acid generated in London in a year, from combustion and respiration, or a mean of 822,000,000 per day, or 34,250,000 per hour, or more than 9,500 cubic feet every second. Now this amount is sufficient to double the normal amount of carbonic acid in 23,750,000 cubic feet of air every second, or in about *fourteen cubic miles*, every twenty-four hours, or more than 5,000 cubic miles per annum. This represents a mass of air of the area of the metropolis, but extending upwards to ten times the height of the Himalaya mountains. How constant and powerful must the varying currents be that produce diffusion through so vast a mass!

The carbonic acid (or carbonic anhydride, as it is now often called) is an important constituent, less, however, on account of its own special action than because we make use of it as a measure of the purity of the air. Its average amount may be taken at 0·400 per 1000 in normal air, although it is not unfrequently below this, and sometimes above it. The mere addition of this gas in a pure state is not attended with poisonous symptoms until a very considerable quantity has been added, as much as 3 per cent., or even more, being 3% found tolerable under certain circumstances.

The causes which produce deterioration of air are numerous, but may be divided into the following:—

1. Respiration and transpiration.
2. Combustion.
3. Sewage emanations.
4. Gases and suspended matter given off by trades and manufactures.

The last division is of comparatively local importance, and has been specially and carefully provided for by legislation; and the question of sewage emanations may be considered hereafter. Combustion, although important in its own way, is comparatively insignificant by the side of respiration, including transpiration, which is really the most serious and constant source of impurity. The chief products of combustion are carbonic acid, carbonic oxide, water, and smoke, which last includes certain empyreumatic matters of varying kinds. Generally speaking, however, special outlets are provided for these, at least when generated in fires, and therefore, except where lights are in question, they may

be practically disregarded. But respiration and transpiration are continually going on at all times and evolving noxious matter into our breathing space, whilst the very last thing that most people think of is the providing either an inlet for fresh or an outlet for foul air.

The changes produced by respiration and transpiration are the following :—

1. The oxygen is greatly diminished.

2. The carbonic acid is largely increased.

3. A large amount of watery vapour is produced.

4. A considerable evolution of ammonia and organic matter.

5. A notable amount of suspended matter is set free, consisting of epithelium and molecular and cellular matter, in a more or less active condition. At the same time portions of epithelium are constantly being given off from the skin, and even pus cells from suppurating surfaces.

The oxygen is of course diminished in the direct ratio of the consumption of carbon and hydrogen in the system. As regards the amount of carbonic acid, this may be reckoned theoretically or deduced from actual experiment. If we take it that a man consumes 3,500 grains of carbon daily, this would yield about 13,000 grains of CO_2, or about 16 cubic feet, but this is only a starvation diet, and an ordinary adult in work requires about 5,000 grains, which would give over 22 cubic feet of CO_2. Now, these quantities would give respectively 0·67 and 0·92 of a cubic foot per hour. Again, if we take a mere subsistence diet, sufficient for the internal work of the body only, we find this to be a

little under 3,000 grains, yielding about 13·6 cubic feet, or about 0·57 per hour of CO_2. Angus Smith, in his experiments, was unable to find more than 0·4 per hour given off, but the experiments of Pettenkofer showed that in a state of repose an adult gave off about 0·7, and in a state of active work 0·9 to 1·0, or more. These numbers correspond pretty closely with theoretical calculation, but if we adopt the number 0·6, to allow for differences of age, weight, and sex, we shall be well within the mark in our calculations.

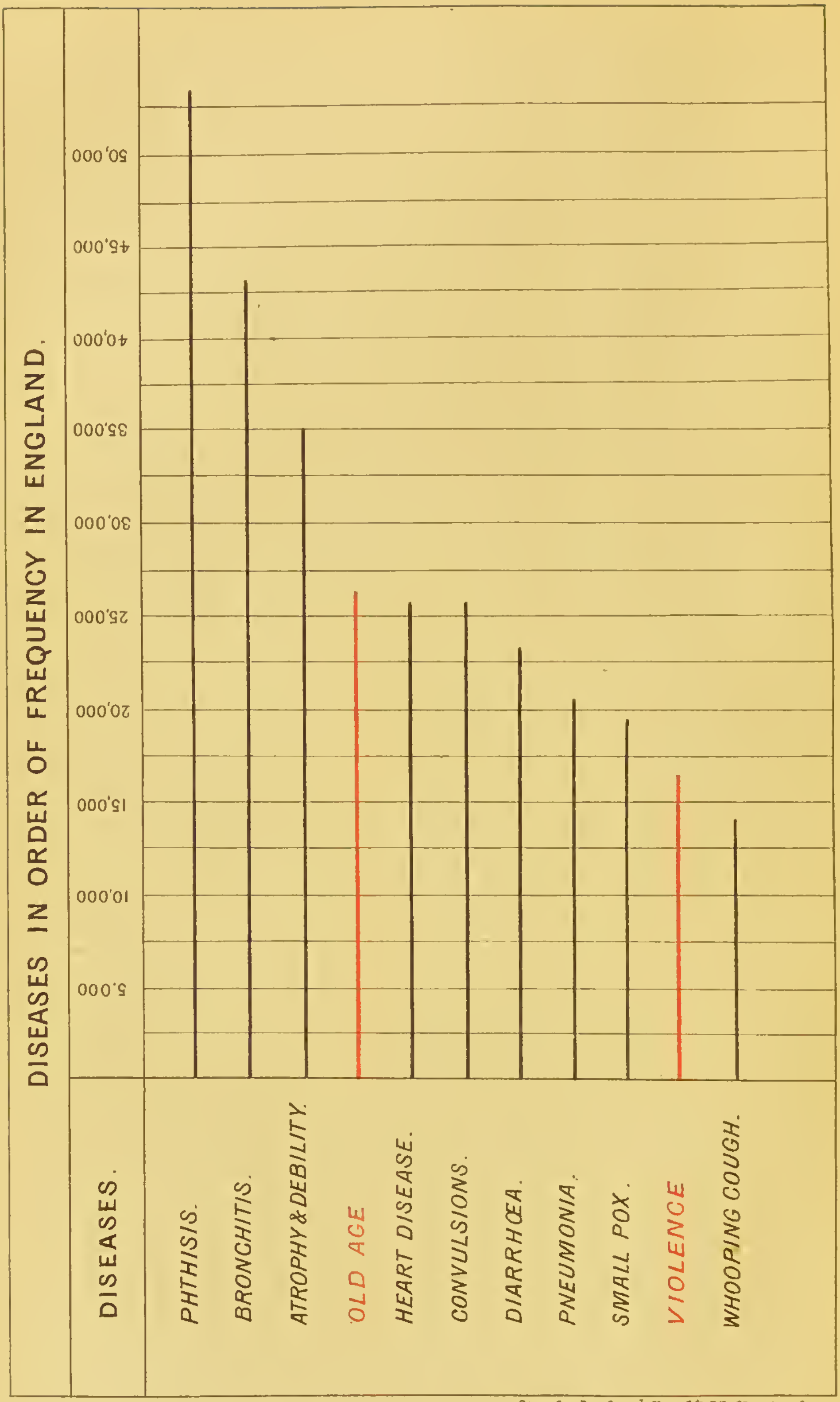
The amount of vapour varies, but, taking the amount from skin and lungs together, it may be taken at about 30 ounces per diem, or about 550 grains per hour, enough to saturate about 90 cubic feet of air at a temperature of 63° F.

The amount of organic matter has been variously estimated, but there are hardly any trustworthy experiments on record. That it is albuminous or nitrogenous is certain, for analysis of the air containing it shows amounts of albuminoid ammonia in the ratio of the impurity of the air. Along with it, or forming part of it, exist certain spherical or oval cellular bodies, described by Lemaire, Trautman and others, and called by Trautman 'putrefaction cells.' These, in all probability, belong to the lowest forms of vegetable organisms, perhaps the starting-points of bacteria, and they bear a strong resemblance to extremely minute bodies found in foul water, which my colleague Dr. Macdonald has called Bacteriform puncta. They appear, in air at least, to be favoured by the presence of sulphuretted hydrogen, and to be arrested by carbolic acid and

other hydro-carbons. It would be impossible to go over all the suspended matters to be met with in air, but they are very numerous, and may be seen in the papers of Dr. Maddox, the report of Dr. Douglas Cunningham, and elsewhere, consisting of various mineral substances, and numerous cells, spores, mycelium, &c., &c. The effects of re-breathing expired air have long been recognised, and hardly require to be insisted on in your presence; yet so slow are people to take in such truths, that the dwellings of the present day are comparatively little improved in the way of ventilation from what they were thirty years ago. It was then that the late Dr. Neil Arnott pointed out the erroneous construction of their dwelling-room as the cause of the deaths of the unfortunate monkeys in the Zoological Gardens, five-sixths of whom died in a month. The room had no outlet but the chimney, and no inlet but some openings near the floor. Now, this is exactly the condition of most rooms in most dwellings, *minus* the openings near the floor, so that they are by so much worse than the fatal monkey-house. The only thing that saves human beings is that in most cases only a part of their life is spent in their homes. Go where we will, however, we shall find that among rich and poor the most constant condition is ill-ventilated dwellings. In the case of the poor, it is aggravated by their very poverty and the tendency to avoid change of atmosphere as entailing lowering of temperature; whilst the sordes attaching to their clothes, persons and furniture, add to the offensive odour of their dwellings. But, without going so low in the social scale, who is

If you [illegible] [illegible] [illegible] [illegible] [illegible]
the exception to these is considered
given for the purpose of [illegible]

Table IV.



Stanfords Geog[l]. Estab[t]. 55, Charing Cross.

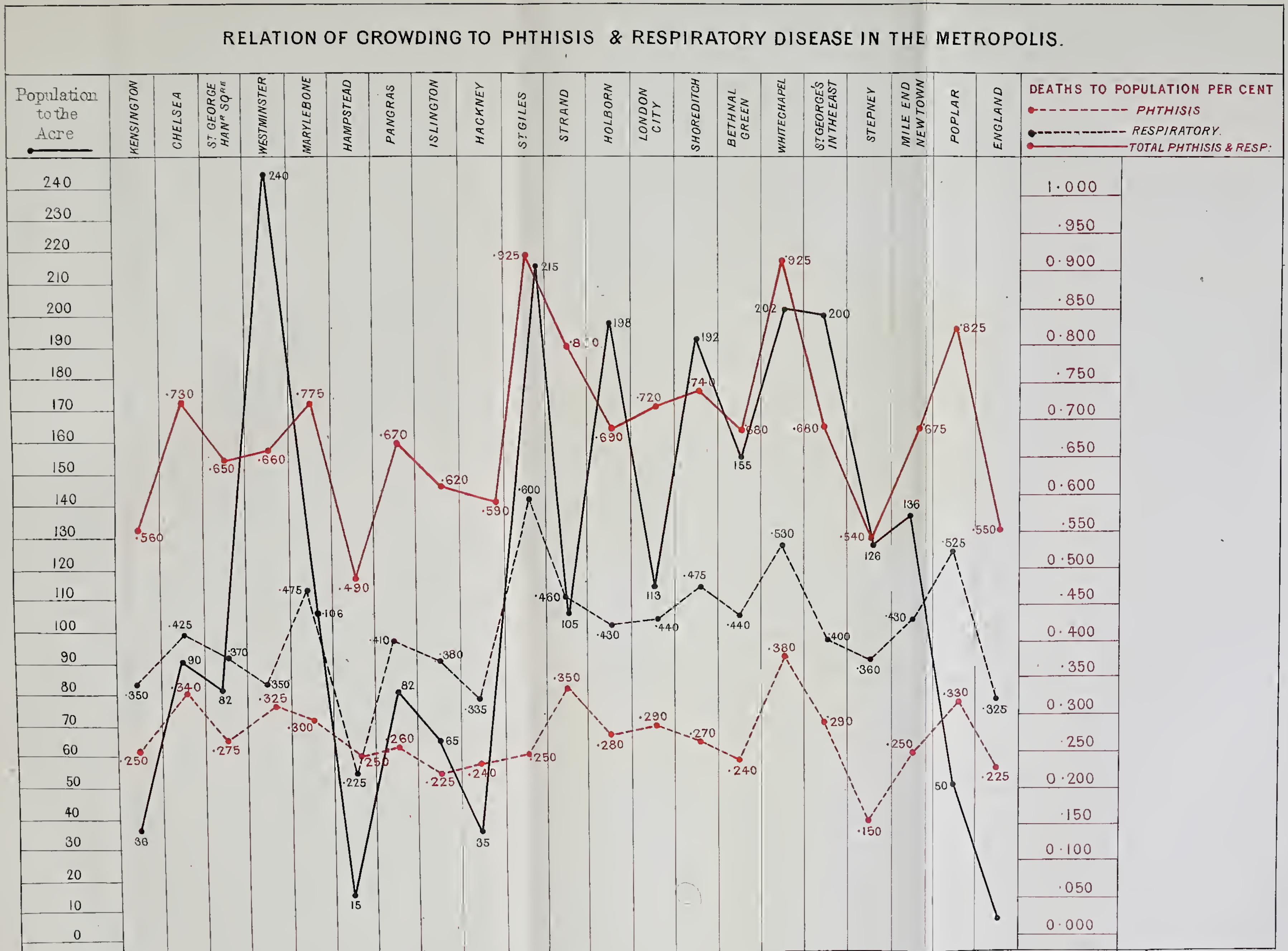
not acquainted with the abominable atmosphere to be met with in theatres, concert-rooms, churches, and meeting-halls, almost anywhere?—whilst ball-rooms, drawing-rooms, dining-rooms, and bed-rooms, even in the best houses, are too often in a most disagreeable and unwholesome state of stuffiness. Now, this being confessedly the general condition in which the population of this country lives, and apparently the only condition that *is* common to all, it is, I think, legitimate to connect it with the prevailing diseases which are the causes of mortality. In the 35th report of the Registrar-General, Dr. Farr gives a table showing the diseases causing death in the order of their frequency, and from it I have constructed the diagram[1] which you see, as an easy means of appreciating the figures. From it you will see that the first place in this fatal list is taken by *phthisis*, which accounts for about 108 deaths out of every 1,000; the second by *bronchitis*, 87 per 1,000; the third, *atrophy and debility*, 61 per 1,000; the fourth, *old age*, 55 per 1,000; then follow in order *heart disease* 53, *convulsions* 52, *diarrhœa* 45, *pneumonia* 41, *small-pox* 39, *violent deaths of all kinds* 39, *whooping-cough* 28. Now it will be admitted that in a truly hygienic community the greatest cause of death ought to be *old age*, and perhaps next to that, *accident*; but here we have *old age* occupying only the *fourth* place, whilst violence of every kind has only the *tenth*, just above whooping-cough. Again, phthisis, bronchitis, and pneumonia alone make up 237 per 1,000, or nearly one-fourth of the total mortality;

[1] See Table.

whilst if to these we add heart disease, atrophy, and debility and convulsions, we have 403 per 1,000, or rather more than four-tenths of the entire mortality. We are therefore entitled I think to connect this great death-rate, particularly that due to phthisis and respiratory complaints, with one constant condition affecting the whole community, namely, breathing impure air. As another means of illustrating this point, I have prepared another diagram,[1] showing the condition of the registration districts of the metropolis north of the Thames, giving the population per acre, with the deaths per 1,000 due to phthisis, respiratory disease, and the two classes combined. It will be then seen that on the whole there is a distinct parallelism between the curves, rough and general as the comparison is. Were more isolated communities selected, the influence would be seen even more markedly. I have already called attention in my first lecture to the influence of crowding upon death-rate, and I now show you another diagram[2] which has some instructive bearings. I have taken from the Registrar-General's data the sub-districts having a population between 80,000 and 120,000; the population per acre is shown by the black curve, and the total population by the dotted curve; the total death-rate per 1,000 by the red curve. Now it will be seen that where the crowding is not excessive the death-rate fluctuates and that it is more steadily parallel to it when the crowding curve rises. This shows that there must be at least one other factor in operation, and this I think may be found, to a certain

[1] See Table. [2] See Table.

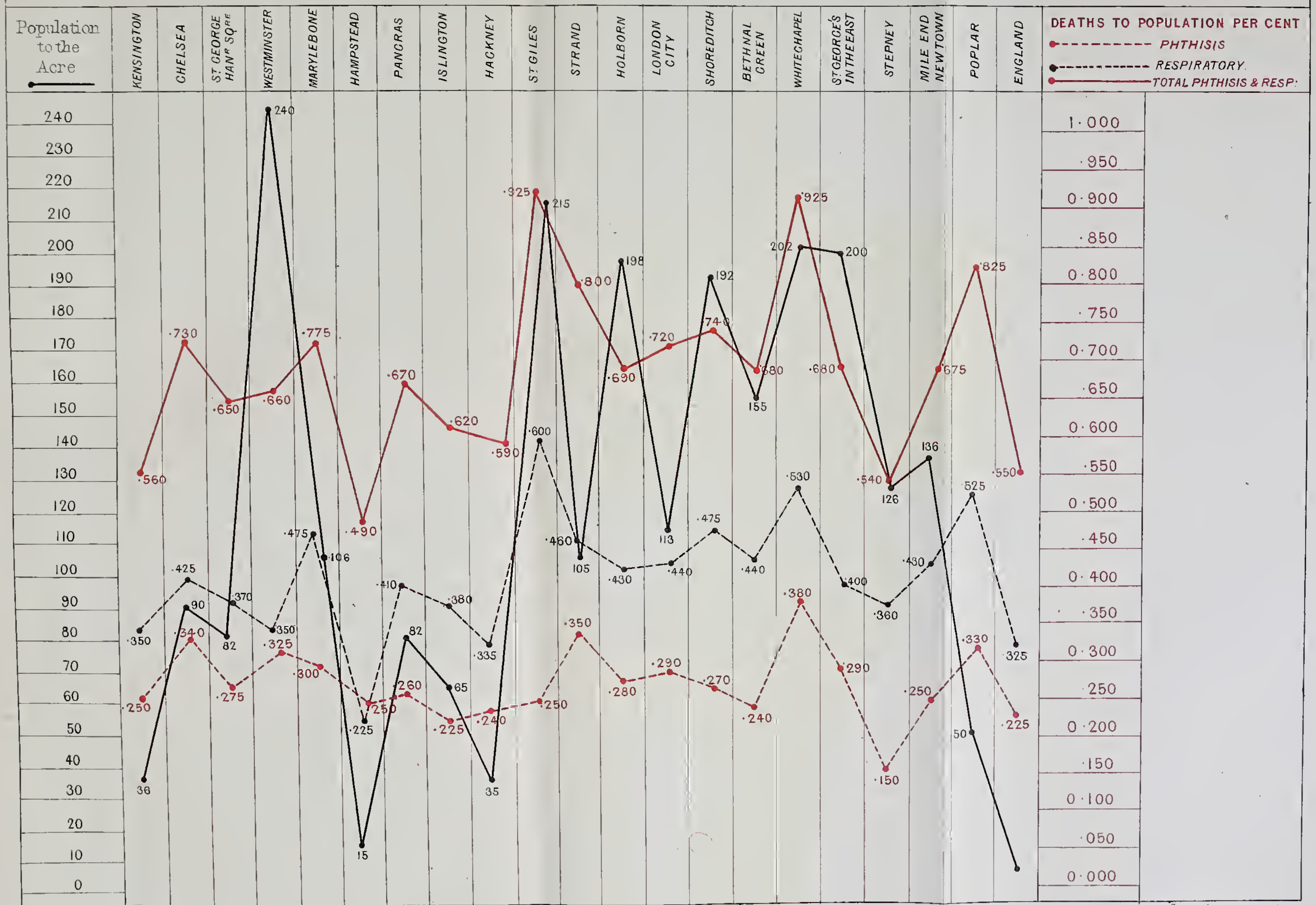
Table V.



Stanford's Geog. Estab. 55, Charing Cross

Table V.

RELATION OF CROWDING TO PHTHISIS & RESPIRATORY DISEASE IN THE METROPOLIS.



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extent at least, in the total population, for the red curve of death is evidently connected with the dotted curve of total population. I look upon this as a proof that the mere bringing together of a number of people into a community, even when there is no excessive crowding, is in itself a source of danger and a reason for state interference. Of course it may be legitimately said that, in some of these cases, when the death-rate rises, there is local crowding causing a rise in the mortality; this is no doubt true, but still the fact remains demonstrable, I think, that the mere aggregation of human beings exercises a powerful influence on their health and vitality. It is further to be noted that, apart from the determination of specific disease, such as phthisis, crowding and foul air tend powerfully to increase the spread of all zymotic diseases, particularly those generally looked upon as contagious. It is therefore not too much to say that, if we could get rid of the effects of crowding, and supply pure air to the community, we might directly diminish the mortality by *one-fourth*, and indirectly materially assist in reducing it by *one-third*. And this by no means represents all the good that might be done, for it is not only in premature death that the state suffers, but also in the lowered tone of the survivors, whose capacities for productive work are proportionately diminished, and who become the parents of a ricketty and useless offspring, little able or willing to keep themselves above pauperism, mendicancy and crime. The question of how to deal with this matter becomes one of increasing difficulty, seeing that our agricultural population is di-

minishing in proportion to the urban, and that, as the people crowd into the towns, attracted by high wages and a more stirring life, they are continually adding to the sources of disease and ultimate deterioration. It therefore becomes a bounden duty, even from the most selfish point of view, to attempt to remedy this state of things. How is this to be done? Mainly by diminishing crowding, and by supplying fresh air; on the one hand clearing out the close noisome dens in towns, and seeing that every dwelling has its own share of light and air, and on the other by supplying in the dwelling itself as much fresh air as will keep it sweet and wholesome. Let us consider this latter point first. The first thing is to decide what our standard shall be; the next, how much air must be given to reach such a standard; and lastly, how this air is to be supplied. As we have seen that nature herself ventilates the globe in the most perfect manner, it is plain that we have only to remove limitations in our dwellings to become partakers of the general blessing. It is also plain that, as our dwellings are almost infinitely small in comparison with the homogeneous atmosphere so successfully ventilated outside of them, it would be unwise to adopt as our standard anything much below the composition of the outer air in purity. At the same time, it would be hardly possible to reach this standard absolutely with our existing means, without exposing the inmates to too violent and dangerous air-currents. It has therefore been proposed to accept as a good and sufficiently ventilated air one that shall present to the sense of smell no marked difference from the outer air.

In a paper read before the Royal Society last January I gave the results of a large number of experiments on this question, which I will briefly describe. The experiments were made in barracks and hospitals among soldiers, so that the characters, habits and general conditions of the inmates were similar. Each room or ward was entered directly from the open air, and the sensation noted at the time, after which samples of the air were collected and set aside for analysis. In this way the fallacy of preconceived notions was got rid of. It is a matter of importance that, in an observation of this sort, the room should be entered as directly as possible from the open air in each case, for the sense of smell becomes only too soon dulled. This must be within the observation of every one, for almost all must have noticed how offensive a room often is on returning to it after leaving it for a little, even when any disagreeable smell had ceased to be appreciated during the previous stay in the room. In this way a truly horrible atmosphere is sometimes tolerated by habit, which would sicken and nauseate a new-comer. In recording the sensations experienced, such terms as 'fresh,' 'fair,' &c. were used to indicate an atmosphere not appreciably different from the outer air; 'rather close,' when the smell of organic matter became perceptible; 'close,' when the smell became disagreeable; and 'very close,' or 'extremely close,' when it began to become offensive and oppressive—this last apparently forming the limit of differentiation possible by means of the senses. The results arrived at, after a considerable number of analyses, were that the mean amount

of carbonic acid existing as respiratory impurity, that is, in excess over the amount in the outer air, when the air gave no appreciable smell of organic matter, was 0·1830 per 1,000 volumes, the mean amount when the air was 'rather close,' that is, when the smell of organic matter was distinct, was 0·3894; when the air was 'close,' that is, when the smell had become disagreeable, it was 0·6322; and when it was 'extremely close,' the smell having become offensive, it was 0·8533. The mean difference of the orders is 0·2133; and the probable error of result of the first order is only 0·0078, the range lying between 0·1908 and 0·1752. I think we may legitimately conclude that the average limit is to be found at 0·2000 per 1,000 volumes, and that any condition which keeps the respiratory impurity within this may be considered good ventilation. Coincidently with this are other conditions of temperature and humidity, which may be summarised as follows:—

Temperature.—The *dry* bulb thermometer ought to read 63° F. to 65° F. and ought not if possible to go much below 60° F.

The *wet* bulb ought to read 58° F. to 61° F. In any case the difference between the two thermometers ought not to be less than 4° F. or more than 5° F.

Vapour ought not to exceed 4·7 grains per cubic foot at a temperature of 63°, or 5·0 grains at a temperature of 65° F.

Humidity ought to range between 73 and 75 per cent.

It may be thought a difficult thing to keep an air down to this particular humidity when the outer air is saturated, as in wet weather; but it must be remem-

bered that the capacity of the air for moisture increases enormously with the temperature, and that what would saturate air at 50° F. would give us only 71 per cent. at 60° F. Thus, at 50° F. a cubic foot of air is saturated by 4·1 grains; but at 60° F. it requires 5·8 grains, so that 4·1 grains would give us only 71 per cent. Therefore, by keeping the room at a proper temperature, the incoming moisture would never be sufficient to raise the humidity, except in the rare cases of an external atmosphere saturated at or above the temperature within, in which case there would be compensation by the possibility of letting in an unlimited quantity of air through every possible aperture. It is the sources of vapour inside the room that have to be looked to; every man, for instance, gives off from lungs and skin each hour enough to raise the humidity from 70 per cent. to saturation in 500 cubic feet at 60° F., and to raise it to 82 per cent. in 1,500 cubic feet. Now, to reduce this amount to 73 per cent. would take 3,000 cubic feet of air saturated at 50° F., or 2,000 at 98 per cent. But as the vapour given off by the body is not the only source of humidity, which may arise from the combustion of lights, or the vapour of liquids used in the room, it is obvious that the highest amount of air is the most advisable to aim at. Consequently, with an initial air-space of, say, 1,000 cubic feet, it will be necessary to supply 3,000 cubic feet per hour to keep the room in its proper condition as regards humidity.

Let us now consider the case as regards other impurities; and here we will take the CO_2 as our

measure. According to the experiments of Pettenkofer, before mentioned, an adult gives off about 0·7 of a cubic foot of CO_2 per hour, with a proportionate amount of organic matter, when at perfect rest; women and children give off proportionately less; and, generally speaking, we may put it at about 8 cubic inches for each pound avoirdupois of body weight. This would bring the average hourly product of men, women, and children to about 0·5 of a cubic foot; but, to be within safe limits, I think that 0·6 is a good number to take, and this number has also been adopted by Dr. Parkes. Now, if we decide, as has been already suggested, upon accepting 0·2 per 1,000 of CO_2 as the limit of respiratory impurity in a well-ventilated air-space, we can calculate out the amount of air necessary for the purpose. For this it is more convenient to state the ratio of CO_2 per cubic foot, so that 0·2 per 1,000 would be 0·0002 per cubic foot, and calling this ρ, the amount of CO_2 given out by a single individual e, and the delivery of air required d, we have:

$$d = \frac{e}{\rho}$$

Now, when e = 0·6, and ρ = 0·0002, we have the following:

$$d = \frac{0 \cdot 6}{0 \cdot 0002} = 3{,}000,$$

or it requires 3,000 cubic feet per hour to preserve the air-space in the required state of freshness. We thus arrive at this quantity of air by two routes, by the humidity and by the carbonic acid, which in this case

we accept as the measure of organic impurity. Of course in rooms occupied by persons in active work, more would be required, as from 50 to 100 per cent. more impurity would be evolved; therefore, in ordinary work-rooms, from 4,000 to 5,000 cubic feet per head per hour would be necessary, and in unhealthy trades 6,000 to 7,000. Some of my experiments were made in hospitals, occupied for the most part by ordinary cases, and I was thus enabled to compare the results with those in barracks occupied by healthy men. I found that the mean amount of impurity in barracks, when the air was noted fresh, was 0·196 per 1,000, and in hospitals 0·157, from which I calculate that the supply of air was 3,062 in the former, and 3,822 in the latter. It thus took nearly *one-third* more air to keep the atmosphere sweet in hospitals, so that we may safely lay it down that in ordinary cases no hospital ward ought to have less than 4,000 cubic feet per head per hour, and that in cases of zymotic or epidemic disease the amount ought to be greatly increased; indeed practically the amount ought to be unlimited, so that many kinds of disease might be advantageously treated in the open air. This is proved by the great success of tent hospitals, both in time of war and in time of peace. In Germany this open-air plan has been practically tried to a great extent, and with very gratifying success. Returning, however, to the question of supplying air in ordinary buildings, there are one or two points to be insisted upon. In the first place, as far as regards gaseous impurities, diffusion takes place according to known laws with

great rapidity, and we cannot, therefore, with safety arrange for anything short of general diffusion. It must of course be admitted that such general diffusion is probably not true of all the organic impurities, particularly such as are in a state of suspension, for in all likelihood the particles tend to settle on the floors, walls, furniture, clothes, and persons of the inmates. At the same time, if the air-space be ventilated on the basis of general diffusion, we shall render such settlement a matter of greater difficulty, and may succeed in driving out a good many of the particles before it occurs. General diffusion, then, being admitted, does the size of the air-space influence the amount of air required? Most people would answer, at first hearing, yes; but practically it does not—that is to say, its influence is appreciable during so short a time that it may be practically disregarded if the space is to be occupied beyond a couple of hours. The following formula was given by the late Professor Donkin at the sitting of the committee for enquiring into the condition of the metropolitan workhouse infirmaries (with other symbols, however):—

$$r = \mathrm{R} + \frac{e}{d} - \frac{e}{d}\,\varepsilon^{-\frac{dh}{c}}$$

Where r is the condition of the air as to CO_2 per foot at the end of the time h, R the CO_2 in the outer air, e the CO_2 expired per hour per man, d the incoming air in cubic feet, ε the exponential function, and c the capacity of the air-space. It will be obvious that if the inmate is in the open air the space c is infinite, so that $\varepsilon^{-\frac{dh}{\infty}} = \varepsilon^{-0} = 1$,

or the evolution of e makes no appreciable change; but where c is any ordinary quantity, the second half of the right-hand portion of the equation becomes rapidly inappreciable, and at the end of the second hour is practically nothing. With it then disappears the quantity c or the capacity of the air-space. It follows then that it is immaterial what the size of the air-space is, for the same amount of fresh air will be needed to keep it sweet, be it large or small. It will therefore not do to attempt to make up for bad ventilation by giving more cubic space, particularly if the increase be perpendicular instead of lateral, for a man may be suffocated in a well, or even in a crowd in the open air, where the space in each case perpendicularly is unlimited. It may be interesting to know the length of time it would take to bring the air to the limit of purity (0·2 per thousand of CO_2 as respiratory impurity) in unventilated air-spaces of different sizes, thus:—

One man in	10,000	cubic	feet,	3 hours 20 minutes.
"	5,000	"	"	1 hour 40 "
"	1,000	"	"	20 "
"	600	"	"	12 "
"	200	"	"	4 "
"	50	"	"	1 minute.
"	30	"	"	36 seconds.

Of course 10,000 or even 5,000 cubic feet is an amount hardly ever met with; 600 is the space in barracks for a soldier; 200 is the space in a cell of Chatham convict prison, 50 is about the space in a bell-

tent with only ten men, and 30 the same when eighteen men occupy it—not an uncommon complement in time of war. It will thus be seen that, take it from any point of view we please, a large amount of fresh air must be supplied to keep a habitation healthy, and that no arrangement whatever can take the place of that air, short of taking the inhabitant out of his house altogether, which means practically giving him an unlimited supply. Of course it must be understood that other considerations come in which make the size of the air-space of some account, namely, the warming of a large space, which becomes expensive, and the supply of air of sufficient temperature to avoid draughts in a small space, so as to allow the air to be changed often enough. These are difficulties of detail which tax the ingenuity of sanitary engineers, but they are being gradually overcome, and will no doubt ultimately disappear altogether.

Our next question is how this air is to be supplied; and the means of ventilation may be divided into two. 1. The natural; and 2, the artificial. By far the larger part of ventilation is carried on by the former, although under some circumstances the latter becomes useful. Let us first speak of the natural method. This is based upon the known law that, of two columns of air of different temperatures, the warmer and lighter will be displaced by the colder and heavier, according to the known laws of gravity. This is shortly the cause of all the air movements in our atmosphere, from the lightest zephyr to the typhoon. Our chief object, then, ought to be to encourage this

natural movement by simply removing obstacles to it. Yet so little is this understood, that a friend of mine, on proposing a very simple plan of ventilation on natural principles, received for answer that the parties 'objected to any plan into which the different specific gravities of columns of air entered as elements'! My friend replied that, as that happened to be the principle on which the universe was ventilated, he did not well see how it could be set aside. I daresay, however, those worthies were descendants of Sydney Smith's man, who blasphemed the North Pole, and spoke disrespectfully of the Equator!

When certain data are known, the amount of air available can be calculated with great precision when proper allowance is made for sources of friction and consequent loss. Unfortunately these considerations are too little regarded by architects and builders, who have been prone to sacrifice to fashion or appearance the more important question of air-supply to the inmates. Much of this is of course due to the fact of want of instruction on this point, which I submit, however, ought to be a part of their teaching. The government now recognise this, and lectures are given on hygiene to the Royal Engineers, who are so frequently charged with the duty of constructing barracks and hospitals.

With regard to the methods of supplying the air, that is, of providing openings for its ingress and egress, I can only briefly allude to some. Up to a very few years ago ventilators were hardly known, and even those were confined to Hale's small fan opening, and

Arnott's stove or chimney valve; but the majority of buildings were quite without them. In some cases the warming of buildings was based upon the closing up of all openings whatsoever. I remember being told of a plan of heating churches, which was said to be formerly much in vogue, and may be still, for all I know, where the air was passed through a sort of oven and redelivered into the building; but the essential part of the plan was that every aperture should be closed. Yet I daresay the parson felt hurt when his congregation fell asleep during the sermon. Many plans of late years have been introduced, some more, some less, successful. For the introduction of air we have the Sheringham valve and its various modifications, McKinnel's double tube, Boyle's and other window-ventilators, Galton's ventilating stoves, Pott's ventilating cornice, and others. The principle of all is either to warm the air introduced, or to bring it in in such a way as to throw it up to the ceiling and so distribute it without draughts. For outlet of foul air the chimney has been chiefly depended upon in ordinary dwellings, and in many cases it is sufficient. But where gaslights are used it is plain that a special outlet should be provided, and this is now often done, especially when a sun-light is the form employed. Other special shafts have been employed in larger buildings, and in most cases the uptake has been assisted by the warmth of the fires or stoves used for heating. Some time ago two medical men of Liverpool, Messrs. Drysdale and Hayward, advocated a plan of having one central uptake shaft for the house, and

delivering the fresh air warmed through the lobby into the rooms. This, however, is objectionable, on the ground that it necessitates the closing of all the windows and other apertures. Now in no case can we dispense with occasional and even frequent perflation, by which much of the evil of the settling of organic particles may be obviated. In too many cases the main error has been providing an outlet (generally the chimney) and neglecting to provide an inlet, one of the main causes of the smoky chimneys of which people so bitterly complain.[1] The essential principle of ventilation is that there shall be *two* openings in a room, one of which shall be capable of acting as outlet, the other as inlet; the details of arrangement depending upon the construction of the room.

With regard to artificial methods, they are applicable only to large establishments, and may be divided into those that force in fresh air and those that extract foul air. Of the former the earliest was the wheel of Desaguliers, used for the House of Commons in the last century, and revived in our day in India, as the thermantidote—the various contrivances by fans and other methods, all of an expensive kind, requiring labour and machinery. After all, they are not satis-

[1] The method of ventilation proposed by Mr. Tobin, of Leeds, has lately excited a good deal of interest, and would probably be of use in many cases. It consists in bringing in air by vertical tubes up the walls of the room, and has been already tried in one or two places. The originality of the plan has been much questioned, although a good deal of extravagant laudation has been bestowed upon it; whilst at the same time some of the recorded experiments said to have been made, or rather the proposed explanations of them, are absurd as being contrary to known physical laws.

factory, and seldom yield the amount of air calculated. I may also mention Hales's bellows, Arnott's pump, and others.

Of the extraction methods, Sutton's was probably the first, introduced for ships of war in the last century; various others have since been tried, including Reid's shafts in the Houses of Parliament, and Jebb's central tower with furnace in the model prisons. Of this last I may say that it appears to have had a fair trial only at Pentonville; but in other prisons intended to be ventilated on this plan the essential part, the lighting of the furnace, has been for the most part consistently left out. At Pentonville it answers partially well in the cells near the tower, but the effect diminishes progressively in the more distant ones. In ordinary dwellings an extraction shaft can be easily arranged round the chimney, the heat of which produces a fairly constant up-current.

In the army, where the effects of foul air have been traced out with remarkable precision, the plan followed by the Barrack Commission has been fairly successful. The principle on which they have gone has been to arrange for warming a portion of the air in winter, and so delivering the cold portion as not to produce draughts. This is accomplished by bringing in air by a horizontal tube under the floor to an air chamber behind the stove, on Galton's principle, and then delivering it by a vertical tube opening into the room thsough a covered opening near the ceiling. The cool air is brought in through valve openings near the ceiling, which throw up the air against the ceiling so

that it falls down in a divided stream. In the Herbert Hospital, and others similarly constructed, an arrangement is made for bringing fresh air into the wards near the floor, but this is applicable for summer use only. The outlet is taken up through the ceiling above the gaselier, where gas is used, then along under the floor of the upper ward, and then perpendicularly up a shaft round the chimney. Where gas is not in use, as in barracks, a special extraction shaft is generally carried up from the corner of the room. Allowance is made for the height of the room according to storey, upper storeys having more ventilation opening than lower or ground-floor ones; but a single-storeyed building is deemed an upper storey for sanitary purposes. Each man has from ten to twelve square inches of sectional area for inlet and the same for outlet, an amount sufficient for the change of air contemplated, viz. 1,200 cubic feet per hour, but not sufficient for the quantity necessary for perfect ventilation, viz. 3,000.

The materials, form and arrangements of dwellings are matters of some importance, although they are frequently but little under the control of the occupant. With regard to materials, these are generally settled by the questions of price and convenience, brick and stone being the most generally selected; the chief objection to stone has been raised on account of its danger in case of fire, it being more apt, according to Capt. Shaw, to split and endanger life. Stone, however, is only attainable in certain places, whilst brick forms the great bulk of building material; houses built of it are too often scamped in a shameful way, and

walls one brick or a brick and a half thick run up, which either tumble down prematurely or are so porous as to be unwholesomely damp. Solid walls are a mistake; in every case there ought to be a space between the outer and inner skin, both to prevent the too sudden cooling or heating of the wall and also to obviate the effects of porosity in wet weather. Unless the outer wall be very thick, and made of exceptionally good material, it ought to be plastered, slate hung, or otherwise covered. The porosity of brick is surprising, and Pettenkofer has shown the possibility of blowing out a candle through a nine-inch brick wall.[1]

In the interior of buildings it is important to obviate, as far as possible, the settling of organic matter, particularly in large institutions where numbers of persons are gathered together. Thus impervious walls and floors are desirable, the former of parian cement or some similar material, or else oil-painted or varnished; the latter of tiles or hard wood oiled, varnished, or polished, or softer wood impregnated with solid paraffin, as proposed by Dr. Langstaff, of Southampton. Where numbers of people are brought together in dormitories, the arrangements ought to be such as to allow fresh air to reach each one without passing over the bed of another. Thus the pavilion plan of building, as practised in the new St. Thomas's Hospital and the Herbert Hospital at Woolwich, is eminently desirable. To obviate also the air of one block passing into another in case of epidemic disease,

[1] This was shown experimentally at the lecture.

it is well to dispose the blocks in echelon, so that the air shall blow directly upon the windows on either side. Under no circumstances ought square blocks, enclosing a space of stagnant air, to be erected.

In the matter of warming, builders have an almost uncontrollable liking for disposing the fireplaces in the most wasteful and objectionable manner, namely in the outside wall, so that a great deal of fuel is taken up in radiating heat into space. The fireplaces ought to be concentrated as nearly as possible in the centre of the house, where they would not only radiate their heat into and not out of the building, but also materially assist the ventilation by favouring the efficient extraction of foul air.

When there is reason to believe that there are sources of impurity in the external air itself, it is possible to a certain extent to arrest them by filtering the air through carbolised gauze or similar material.

Existing legislation. — The existing legislative measures bearing on the supply of fresh air and the arrangements of dwellings are on the whole few, partly from the difficulty of laying down definite rules which admit of rigid application, and partly from the difficulty of dealing with conflicting interests and questions affecting personal liberty and the supposed inviolability of an Englishman's house. That this last, however, is not so great a barrier as it seems is proved by the fact that in Liverpool power of inspection is assumed at any time, so that a house in the lower parts of the town may be entered in the night to see that it is not overcrowded. This appears to be carried on there

without much trouble, and what may be applied in one place may be applied in another. The acts of Imperial legislation have, however, limited themselves for the most to granting powers to the local authority, who may frame bye-laws with respect to ventilation and crowding, chiefly, however, with reference to lodging-houses. The following are the rules laid down in the regulations issued by the Secretary of State, *e.g.* :—Rooms used as kitchen or scullery, or on the basement or below the level of the ground, shall not be used for sleeping apartments. The windows of every sleeping-room shall be kept open to the full width thereof from nine to eleven A.M., and two to four P.M., unless prevented by tempestuous weather or by the illness of any one in the room. Further, the keeper ot the lodging-house shall cause every room to be ventilated to the satisfaction of the inspector. In the regulations adopted by the Board of Works for the Poplar district, it is provided, in addition to provisions already mentioned, that no room not lighted and ventilated directly from the exterior shall be used as a sleeping-room. If the room is to be used only as a sleeping-room at night, each person shall have 300 cubic feet of space, and if used as a day-room as well, at least 400. The Board has power to direct the construction of windows, window sashes, and chimney flues for ventilation purposes. Provisions for night inspection are also made. All these regulations are good, and the result is that the tramp and vagrant is often in a much more wholesome condition than the honest labourer, or even artisan. The provisions of the Acts

dealing with the dwellings of the latter chiefly relate to premises dangerous to life and health, but I fail to gather from them that any special provision is made to ensure ventilation and prevent overcrowding. Their main action is to compel the landlords to put in tenantable repair dangerous fabrics, or to demolish them, if past mending. In the Bill before Parliament at present[1] the chief provisions are powers to demolish crowded portions of towns, which are known to be nests of disease, and to provide dwellings for those persons formerly occupying those places. This is an excellent provision if it can be properly carried out, and, for my own part, I think the objections have been chiefly theoretical. There is no doubt that immense benefit has been effected in some places, for instance in Glasgow, as was cited in the House in support of the Bill. In Edinburgh also an immense deal has been done of late years in opening up the oldest and dirtiest parts of the city, with a marked improvement in its sanitary condition. Lately I saw it mentioned that there had been only two cases of fever reported in the city in three weeks, and that during a whole week not one case had occurred. This, I venture to say, has hardly been paralleled in former times. I remember, when I was a student there, that a man who was a clinical clerk or a dispensary pupil for more than six months might pretty well lay his account to getting an attack of typhus, of which I had personal experience. Now-a-days, I fancy, it is hard to get a case to lecture on.

[1] May 1875.

I think that there are certain main principles that might be laid down in legislating for the condition of dwellings, both with regard to their internal arrangements and their position as regards each other. In the first place, no street or court ought to be allowed to be built that is a *cul-de-sac*; all ought to be open at both ends. A certain width ought to be laid down as a minimum, so that both sides should have a fair share of light as well as air. A limit ought to be put to the length of streets, unless broken at intervals by cross streets or roads; open spaces ought to be made compulsory at certain places. No cellars or underground rooms ought to be allowed to be occupied as sleeping-rooms at any time. At present such rooms are only allowed under certain restrictions as to height, both total and above the roadway, size of window, &c. No closet or room without an opening direct to the open air ought to be occupied as a sleeping-room. A chimney flue or shaft leading to the open air ought to be required in every room. Not less than 400 cubic feet per head ought to be given in each sleeping-room, and not less than forty square feet of floor space. This would be a space six by seven by ten, surely no excessive amount. Every window should be made to open, and each inmate ought to have not less than ten square inches of inlet and as much of outlet, which may be provided by means of the chimney and window ventilators, or else by some special openings, but at least *two* openings ought to be insisted upon in order that a current may be possible. The rooms ought to be so arranged that free perflation or flushing

with air periodically may be possible. Where gas is burned a special opening ought to be provided to carry off the products, and this might act as the ordinary ventilator. The proprietor or occupier might be left free to adopt any particular kind of ventilator he might prefer, at least until some special method is proved to be markedly superior to all others. Powers of inspection would of course be required to enforce such regulations. Perhaps it may be long before such measures can be carried, but a beginning might be made by requiring them to be enforced in all new buildings, and they might then be gradually applied to the old. Other points might be suggested, but I am convinced that these, if even partially accomplished, would go a long way towards diminishing the dire array of diseases which is year by year cutting off so many in their prime and leaving the unhealthy and scrofulous survivors as a woful legacy to posterity.

LECTURE III.

ON WATER—ITS PURITY—AND SUPPLY—DUTIES OF THE STATE WITH REGARD TO IT.

Importance of water.—After air, water is certainly the first requirement for existence. Its elements form about four-fifths of the human frame, and without its agency no function would be possible, so that, when Thales called it the beginning of all things, he evinced a keen perception of its true importance, and enunciated a great principle, for which he has been ridiculed by smaller minds. I place it before food because it is contained in all food, which would be unassimilable without it, and also because life can be sustained longer by water alone than by food alone, meaning by this, of course, so-called solid food. It is the nearest approach to the universal solvent so much sought for by alchemists, ancient and modern. Its incompressibility in its liquid state and its elasticity in the gaseous state furnish us with our most powerful mechanical forces. It is the most effective agent for personal cleanliness, for the purification of our clothes, dwellings, and soil itself. It supplies us with a means—perhaps only too easy sometimes—of removing effete substances from our immediate vicinity, and it doubtless plays an important part in washing the very air itself. Under

all circumstances a copious supply of water is necessary for true hygienic conditions, and a community will usually be found to be unhealthy in proportion as the supply is scanty—scantiness of supply not only implying imperfect cleansing, but also impurity in quality in the large majority of cases. Water is also of prime importance in its relation to disease as an agent in its propagation. I have already referred to the recognised fact that any sudden outbreak of disease in a community may be most generally attributed to something wrong in the water supply, and, in spite of the opposite views of some observers it must be looked upon as a very frequent carrier of *materies morbi*.

Composition of drinking-water.—For perfectly pure water we must go to the laboratory of the chemist, and even there we shall find it difficult to get it free from all extraneous matter. Rain water, collected in perfectly clean vessels, is the nearest approach to purity to be found in nature, but even in its best condition it contains, when unfiltered, a notable quantity of suspended matter. Ordinary spring or river water, however, always contains a certain amount of dissolved matter, varying from a grain or two in the gallon in exceptionally pure districts to a hundred times as much, according to the degree in which it is exposed to sources of impurity. These constituents may be variously divided, but perhaps the following is the most comprehensive division :—

A. Gaseous contents.
B. Dissolved solids.
C. Suspended matter.

These may be further divided :—

A. Gaseous contents.

a. Useful gases	1. Carbonic acid. 2. Oxygen 3. Nitrogen	Atmospheric air.
b. Noxious gases	1. Hydrogen sulphide 2. Ammonium sulphide 3. Ammonia	Results of decomposition.

The dissolved solids may be divided into mineral and organic, with an intermediate class, thus :—

B. Dissolved solids.

a. Mineral matter	1. Calcium. 2. Magnesium. 3. Chlorine. 4. Sulphuric acid. 5. Phosphoric acid. 6. Sodium. 7. Potassium. 8. Iron. 9. Silicon. 10. Manganese. 11. Aluminium.
b. Products of organic oxidation	1. Nitric acid. 2. Nitrous acid. 3. Ammonium salts.
c. Organic matter	1. Capable of putrescence or oxidation 2. Incapable of putrescence or oxidation, *e.g.* urea, fatty acids.

The suspended matter may be divided thus :—

C. Suspended matter.

a. Mineral matter	1. Crystallised. 2. Amorphous.

b. Organic matter	I. Dead or incapable of reproduction	1. Amorphous matter.
		2. Organised but decaying, such as fragments of plants, remains of animals, portions of excreta.
		3. Fibres and other parts of clothing, furniture, &c.
		4. Epithelium, pus and other cells from men and animals.
	II. Living and capable of reproduction	1. Spores, seeds, pollen, &c., of plants.
		2. Minute bacteridia, fungi, &c.
		3. Infusorial animals.
		4. Annelids, crustaceans, arachnids, &c.
		5. Eggs, &c. of parasitic and other animals.

The characters of good drinking water are as follows:—A. *Physical.* It should be colourless, inodorous, and have no taste except a clear sparkling taste, which just relieves it from the imputation of flatness. This ought to be due solely to the dissolved gases, viz. the carbonic acid and the atmospheric air. It is a common error to attribute the taste of water to the salts present in it, but it may be safely laid down as a rule that when we begin to taste the salts in water it is high time to throw the water away. From a number of experiments I made some years ago, I found that common salt required to be present to the extent of 70 grains in the gallon before any taste was perceptible, and that even of the more acrid salts, such as calcium nitrate and the magnesian salts, there required to be from 15 to 30 grains. For a water to taste well there ought to be about 6 cubic inches per gallon of CO_2, and about 8 or 10 cubic inches of atmospheric air.

There ought to be no suspended matter or sediment of any kind, so that it ought to be perfectly clear, allowing small print to be read through it at a depth of two feet. Although too much importance must not be given to the physical qualities, we may confidently say that a water that is not clear, colourless, tasteless (except as above limited), and inodorous, is not a first-class water.

B. *Chemical characters.* The following substances ought to be entirely absent, viz. :—

1. Nitric acid.
2. Nitrous acid.
3. Ammonium salts.
4. Metallic salts.
5. Organic matter in excess.
6. Alkaline sulphides.
7. Hydrogen sulphide.

It is rare that all the above are absent ; but, when present, only slight traces ought to be admissible.

Of the substances to be admitted in good drinking water, the following are the quantities :—

Chlorine, under 2 grains per gallon, = 28 milligrammes per litre.

Lime, under 3 or 4 grains per gallon, = 43 to 57 milligrammes per litre,

except a chalk water, which may have more.

Magnesia	only traces.
Phosphoric acid	,,
Sulphuric acid	,,

Total solids, under 8 grains = 114 milligrammes.

Volatile solids, under 1 grain = 14 milligrammes.

Free ammonia, 0·0014 = 0·02 milligrammes per litre.

Albuminoid ammonia, 0·0056 = 0·08 milligrammes per litre.

Oxygen, for organic oxydisable matter, 0·035 = 0·50 milligrammes per litre.

Fixed hardness, under 2° = 28 milligrammes per litre.

The only exceptions are the chalk waters, which contain more lime, and chloride and carbonate of sodium waters, in which the solids may go a little higher, provided the sources of their salts are inorganic. Any change from the above, however, at once removes the water out of the category of first-class waters. The changes which a water undergoes are numerous, varying with the cause. The most frequent source of impurity is the introduction of sewage matter; next to that, the percolation of refuse matters of different kinds from sinks, ashpits, &c.; impurities from graves of men or animals; impurities from manufactories, slaughter-houses, &c. An increase in mineral matter, whether dissolved or suspended, is only of subordinate importance; whilst an increase in such substances as nitric and nitrous acids and ammonia is only evidence of previous contamination of a dangerous kind, but no proof by themselves of existing danger. But a notable increase in oxydisable organic matter, or in

organic suspended matter, whether organised or not, is always to be viewed with the gravest suspicion. Excess of fixed lime salts and magnesian salts is apt to produce dyspepsia, occasionally diarrhœa, and to aggravate dysentery and affections of the mucous membrane generally, especially among the aged, the delicate, and infants. Magnesian salts have been credited with the production of goitre, whilst others have attributed this disease to metallic sulphides. Mineral matter in a suspended form sometimes causes severe intestinal irritation, as has been noticed with finely divided silica, scales of mica, &c. Some mineral constituents may exist very largely without any apparent effect, such as the alkaline chlorides and carbonates, and, to a less extent, the alkaline sulphates. The chlorides are, however, important as indications of the presence of sewage, and sometimes form a guide as to the channel by which organic matter has reached the water. Thus, if we find a good deal of organic matter present, with only a small amount of chlorine, we may conclude that sewage in the solid or liquid form has not been the cause, but that in all likelihood the source of impurity is gaseous. I may mention a case in point. A friend of mine, living in one of the metropolitan districts, asked me to analyse the water from his house, as he had reason to suspect it on account of a case of typhoid fever having occurred. On doing so, I found a considerable excess of organic matter as indicated by the albuminoid ammonia, but a very small quantity of chlorine. He afterwards sent me a copy of the analysis, made by a competent chemist, of the

water from the company's reservoir; here the chlorine was almost identical with mine, but the organic matter was extremely small. I had no hesitation in saying that no liquid sewage had got into the water, but recommended that the overflow pipe of the cistern should be looked to. This was done, and it was found to pass directly into the drain of the house, with a trap, but without disconnection. On this being remedied, the organic matter, on subsequent analysis of the water, was found to have very largely decreased.

First time examined, October 4, albuminoid ammonia . . . . 0·508.
Second time, November 11, after the pipe had been disconnected . . . . . . 1·121,

showing how rapidly the contamination had increased.

Third time, November 28 . . . . . 0·138,

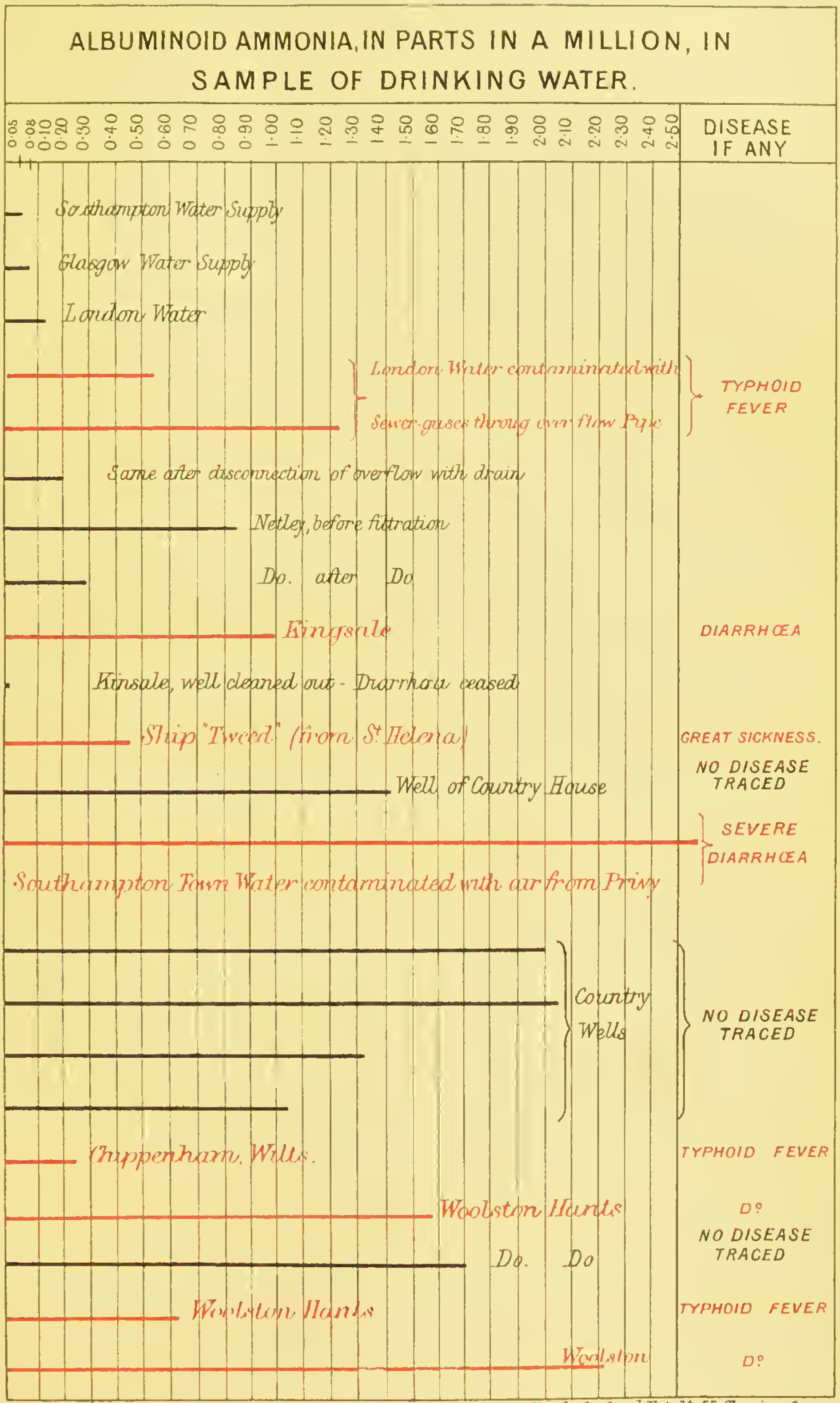
water returning to its natural state. This is shown in the diagram, Table VII.

It is still a moot question as to whether it be the dissolved or the suspended organic matter that is the more dangerous substance, and evidence is still wanting on the subject. There seems to be some reason to think that the suspended matter is the more dangerous, and this would stand to reason if we accepted entirely the germ theory of disease. At present, however, we are scarcely in a position to do this absolutely, and nothing could be more rash than to jump to the conclusion that the dissolved organic matter could be held blameless. There are various ways of estimating this, the

chief of which are Frankland's method of estimating the organic carbon and nitrogen; Wanklyn's method of estimating the albuminoid ammonia; and the estimation of the amount of oxygen required for oxydising the organic matter by the permanganate process. The first is a method of considerable difficulty, and in the hands of any but an accomplished chemist likely to give discrepant results; whilst the two latter, although confessedly imperfect, are yet easy of application. Neither gives absolutely trustworthy results, but the combination of the two is often useful. A reference to the diagram[1] will show the amounts of albuminoid ammonia in a large number of cases analysed by myself, except the Glasgow and London water supply. Taking the Glasgow (Loch Katrine) standard, ·08 per litre, it will be obvious that many of the samples exceed this enormously; those which were coincident with ascertained disease are given in red; those where no disease was positively known, in black. It may be seen that in several cases with a small amount of albuminoid ammonia specific disease was present, whilst in others with a much larger amount no disease was traced. Thus we have typhoid fever with 0·27 at Chippenham; with 0·508 in London; with 1·600 at Woolston; with 0·533 and 2·203 both at Woolston. Again, we have diarrhœa with 1·00 at Kingsale; with 2·800 at Southampton; with 0·384 at Woolston; with 0·11 on board the ship 'Tweed,' accompanied by other disease. On the other hand, no

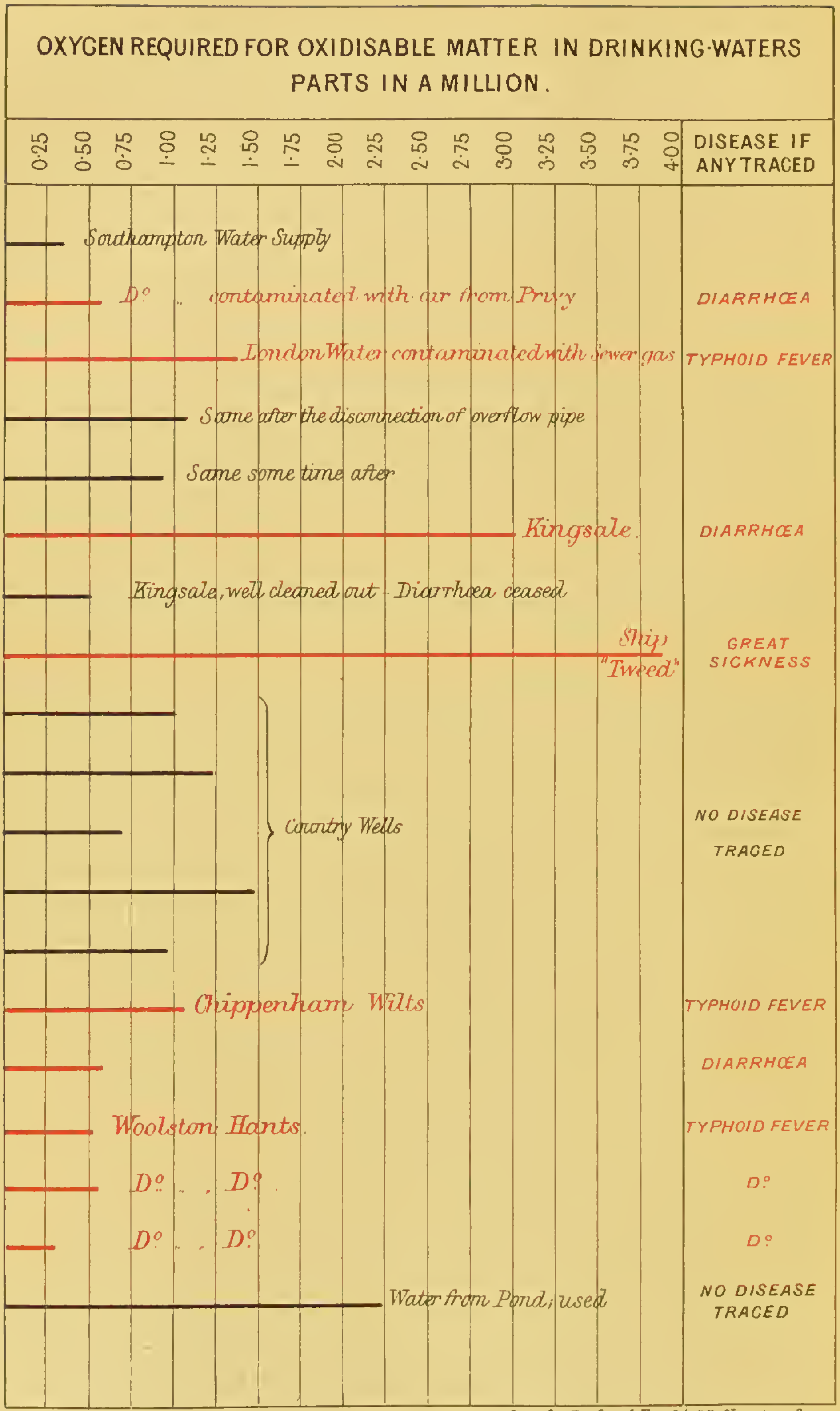
[1] See Table VII.

Table VII.



Stanford's. Geog^l. Estab^t. 55. Charing Cross.

Table VIII.



Stanfords, Geog.l Estab.t 55 Charing Cross

disease was traceable with 0·70, 0·62, 1·400, 1·386, 1·276, 1·6296, at various places. With regard to the last case, it occurred in the same road a few doors from a case of typhoid fever above referred to, and there was no doubt that sewage was getting into the well, for the water smelt strongly of carbolic acid after this had been put into the privy close by. The inmate, however, a sweep, did not seem much moved by the circumstance, and said the water made very good tea! We may therefore infer that, useful as the albuminoid ammonia test may be, it is still an imperfect one, and gives us but a rough notion of the nature of the peccant matter. Probably in some cases the source of it is vegetable and consequently innocuous, and this is in all likelihood the explanation of some of the apparently anomalous results. Turning to the oxygen required for the organic matter we find apparent discrepancies also, but still on the whole disease is coincident with large amounts—in some cases corresponding with the albuminoid ammonia, in others supplementing it.[1] We are therefore fairly entitled to say that there is a connection between excess of organic oxydisable matter in water and certain diseases, chiefly of the zymotic class; such as enteric fever, cholera, dysentery, and diarrhœa, and probably also a number of others. To support this there is a large mass of evidence which it seems to me very difficult to combat, and yet there are a number of competent observers who are inclined either to ignore this in-

[1] See Table VIII.

fluence altogether, or at least to attach to it only a secondary importance. Among these has appeared very prominently of late my friend Dr. James Cunningham, the Sanitary Commissioner of Bengal, who has, in contradiction to his earlier views, boldly advanced the opinion that cholera is never propagated by means of water. One of the arguments is that the disease always travels up rivers and never down, as it might be supposed to do if water carried it; but in answer to that we have the fact that the home of the disease is at the *mouth* of the Ganges, so that it must travel up stream if it moves at all. The truth is that error is likely to be committed by riding a theory too hard; it is just as wrong to say that water is the only channel of cholera as it is to deny its influence altogether. But I think we are entitled by evidence (such as the Broad Street pump case of the late Dr. Snow) to say that water is at least one of the channels through which the poison of cholera is conveyed. The same may be said with equal confidence as regards typhoid or enteric fever. If this point be accepted it is immaterial at present to discuss the question of the spontaneous origin of disease; it is sufficient for our purpose to know that the poison, however it originates, may reach us through water. It would be impossible to lay before you a tithe of the evidence on this point, but I may refer to one or two marked instances of recent years. I have already referred to a case which took place in London, which was apparently traceable to the contamination of the drinking water through the overflow pipe passing

directly into the drain. Dr. Stallard cites a similar case occurring in a school under his observation. Then we have the remarkable cases of typhoid poisoning through the adulteration of milk, investigated in London by Dr. Ballard; another equally marked at Parkhead, near Glasgow, reported by Dr. Russell; and another at Armley by Dr. Coleman. In the Marylebone case, out of ninety-seven families, only eight are stated to have had their milk from other than the infected dairy. In the Parkhead case, thirty-two families, yielding forty-six cases, were supplied with milk from a dairyman who had typhoid in his family—only seven families yielding seven cases elsewhere. At Armley *all* the earlier cases up to July had dealt with a dairyman in whose house there was enteric fever. Perhaps two of the most instructive cases are those of Millbank prison and Pentonville. The condition and history of the former was carefully investigated by Dr. de Renzy. It was first opened in 1816; it is a cell prison, accommodating from 600 to 1,200 convicts; its water supply used to be pumped from the Thames opposite and purified by filtration; during that time, up to 1854, it was very unhealthy, typhoid and cholera having frequently shown themselves. On August 10, 1854, the water supply began to be drawn from the artesian well in Trafalgar Square, at a time when cholera existed in the establishment; six days afterwards it suddenly ceased, and has never recurred. Since that time also only three cases of enteric fever have occurred, and one of these was imported. On the other hand, Pentonville prison, supplied from a

deep well in the chalk, has never suffered from cholera or typhoid.[1] I may cite another remarkable case reported by Dr. Zuckschwerdt, viz. the occurrence of typhoid fever in the Orphan Asylum, at Halle, in 1871. This asylum forms a mass of twenty-nine houses, which are inhabited by about 700 persons, whilst besides those the nine establishments are visited by about 3,000 persons. Cholera has never visited it, although since 1832 it has been six times epidemic in Halle, whilst although typhoid continually prevails in the town no case had occurred in the asylum from 1856 to 1870, and only eighteen from 1820 to 1855. Now at a time when typhoid did not prevail in the town there sickened within four weeks (end of July to August 18, 1871) over 300 persons, on account of which the school was shut up. The numbers were 279 among the inmates, of whom seventeen died, and seventy-seven among the 'passanten' or day visitors, of whom two died. Neither closets nor soil could be blamed; the former open into the town ditch, the channels lie open and free to the wind, and are deeper than an impervious clay stratum, so that no drainage can get towards the houses. Contagion does not explain it, for the attack was too sudden and generally distributed, whilst the 2,400 day scholars caused no epidemic in the town, and of the 120 boarders already sick, who were sent out to ninety different places, only nine appeared to become foci of

[1] I may also refer to the cases at Terling and Whitchurch, reported by Dr. Thorne; at Guildford and Ecton, by Dr. Buchanan; at Nunney, by Dr. Ballard; and others.

disease. The drinking-water is brought through two channels, of which one comes from a gravelly soil about 2,000 mètres off, and delivers 1,000 litres in twenty-four hours. This channel became defective in the winter of 1870–1, so that the drainage of the Lindenstrasse (where typhoid prevailed) was able to trickle into it. This defect was repaired in April 1871, but in July and August of the same year the earth sank in this place and made a puddle. The drinking-water contained bacteria, vibriones, thread-worms, &c., and was identical in smell and colour with the contents of the puddle. The channel was closed on August 11, and on the 18th the last case of sickness took place. It is right here to note that the writer has included all cases of febricula as well as true fever, as may be seen by the small death-rate; of 356 cases, ninety-seven are noted as severe, 259 as slight.

Both dysentery and diarrhœa have been frequently traced to impure water. With regard to cholera, I think the evidence existing is sufficient to trace a very important influence to impure water. In addition to the Broad Street case, I may refer to the East London outbreak in 1866, to the importation of cholera into Southampton in 1866, to the evidence of the Hurdwar epidemic in India, and to numerous other cases. I have myself seen cholera attack one party of men and not another, where the only apparent difference traceable was the purity of the drinking-water. The chief objection urged is that people who drink contaminated water do not always take cholera, as they ought to do if the theory were true, but the same holds

good of typhoid, and goes only to show the probability that a specific contagium is necessary as well as also a favourable nidus. One thing is certain, that whenever care has been taken to secure an improved supply of drinking-water, cholera has lessened in intensity, and enteric fever has greatly diminished. And it is a comfort to find that even the most strenuous opponents of the water theory still admit the collateral influence of its impurity, as well as of other hygienic *lâches*; so that whichever view is held it need not make us abate our exertions one jot in the direction of improvement.

When we come to the question of separating the *materies morbi* itself, we find ourselves surrounded with difficulty, and we are obliged to confess the deficiency of our knowledge. That it is an organic poison is most probable; that it is organised and capable of propagation seems likely, but beyond that we are not in a position to go. The animal and vegetable life in water has been much studied, and we make it a part of our hygienic course at Netley to investigate it. You will see on the diagrams[1] some of the chief types to be found—ranging from the crustaceans and annelids down to the most minute monadic and bacteroid forms. It seems very improbable that the larger and higher organisms are themselves active in producing disease, although their presence may be taken sometimes as measures of water purity. For instance, it is the opinion of some[2] that *paramecium*

[1] This part of the lecture was illustrated by wall-diagrams, showing the chief types of animal and vegetable life.

[2] *E.g.* Hassall.

is especially characteristic of sewage water, and some have even gone so far as to consider the possibility of spontaneous generation of that animal from sewage; others look upon the presence of *Euplotes* as an evidence of great impurity in water. There is one thing quite certain, that the existence of those creatures in a thriving condition is always coincident with an excess of organic matter as measured by the albuminoid ammonia; whilst a deficiency of the latter causes wasting and death among the infusoria. An instance of this was found by Dr. Macdonald and myself in the examination of some samples of bilge-water, which contained a comparatively small amount of albuminoid ammonia; there was a remarkable absence of life, the few infusorial animals present being either dead or in a pallid and flaccid condition. The tendency of recent years has been to attribute more influence to the lower forms of life, which appear to be chiefly vegetable, such as the bacteria and fungi; both of these classes are found in abundance in impure water, but the great difficulty is to connect any one of them with any special morbid condition. In Cohn's plate may be seen his division of the forms of bacteria, starting from the bacteriform puncta (or micrococci as he rather unfortunately names them) and proceeding up to the vibrio, spirillum, and spirochæte. Now, the sediment of the water of one of the wells at Netley Hospital (the water being pure to the eye), collected by letting down a slip of glass to the bottom of a long vessel, on which in time the suspended matter slowly settled, showed on examination a number of organisms.

Besides several forms of euglenia and a good deal of inorganic matter, there was present a zooglœal or palmoglœal mass containing forms which it is hard to distinguish from Bacterium Termo. They were quite motionless as long as they were engaged in their jelly-like frond, but when separated acquired the motion peculiar to bacteria. Yet this water has been much used, and no sickness of any kind has been traced to it. Of course it may be argued that, although the bacterium itself may be innocuous, it may form the means of carriage of the poison of disease. Under any circumstances, we shall certainly be safer without it; and one of the first qualities to be required of really good drinking-water is a total absence of suspended matter of every kind. Another important point is the production of parasitic disease through water, of which there is now ample evidence.

Means of purifying water.—The means of purifying water may be divided into these applicable on a large scale, and those adapted for domestic use. For the former purpose the water may be allowed to settle until the suspended matter subsides, and it may then be passed through filter-beds of sand and charcoal. Sand and fine gravel arrest suspended matter to a considerable extent, and they even stop an appreciable amount of salts. This explains the otherwise anomalous fact that fresh water is often obtainable close to the sea, where there is good reason to believe that the supply is really obtained from the sea, filtered through sand or sandstone rock. But charcoal must be looked upon as the great purifier, both for large and small quantities.

Its effects in removing organic matter are very considerable.

The plan employed by the London water companies is to use sand and fine gravel, in the proportion of fifteen inches of the former to twenty-one of the latter for a three-foot filter. Dr. Parkes made a number of experiments with such a filter, and found that it had a very considerable effect. It took away three-quarters of the colour, and it lessened the constituents as follows :—

Total solids	7·063	grains.
Mineral ,, ...	4·703	,,
Volatile ,, ...	2·360	,,
Total amount of oxygen required for oxidation by nearly a half or	0·1546	,,
Hardness by	4·6100	,,
Chlorine by	0·6000	,,
Free ammonia . . .	0·0042	,,
Albuminoid do. . . .	0·0126	,,

Finely divided clay appears to be, of all the suspended matter, that which passes through most easily. The influence of sand, although considerable, is still limited, and to purify water charcoal is absolutely necessary. Extensive experiments have been made, and the general result appears to be that animal is greatly superior to vegetable charcoal of any kind. It seems not only to arrest but to destroy organic matter to a considerable degree, converting it into nitrogen acids. From experiments by Dr. Parkes on small filters, it was found that the average removal of organic matter

was 74·5 per cent.—from 96 in the best to 56·2 in the lowest. Major Crease, of the Royal Marine Artillery, has invented an excellent filter for ship and barrack use, consisting of an iron box or cylinder, lined with a patent cement that completely protects the iron, and filled with animal charcoal in small fragments, screwed down tight. There is a considerable depth of charcoal, and its action is excellent. Dr. Frankland has proposed that town supplies should always be filtered through animal charcoal, and it certainly would be an excellent plan if the expense were not against it. To obtain pure water, however, even a large expense would be wisdom, and there seems to be no other practical difficulty, as it is certain that the water can be got through sufficiently rapidly. In all cases the power of charcoal, like that of everything else, is limited, and it must therefore be cleaned from time to time, either by washing with distilled water or with permanganate solution, or, better still, by heating it to low redness. The main objection to ordinary filters is the impossibility of getting at the charcoal for the purpose of cleaning, and it is one of the merits, not the least too, of Major Crease's, that this can be easily done. Numerous patents have been taken out for self-cleansing filters, which are partially successful, but in some cases almost too ingenious to be permanently useful.

Quantity of water.—Having discussed the quality of water, let us now turn our attention to the quantity necessary for health. A man requires a certain amount as drink, varying with size, health, and temperament,

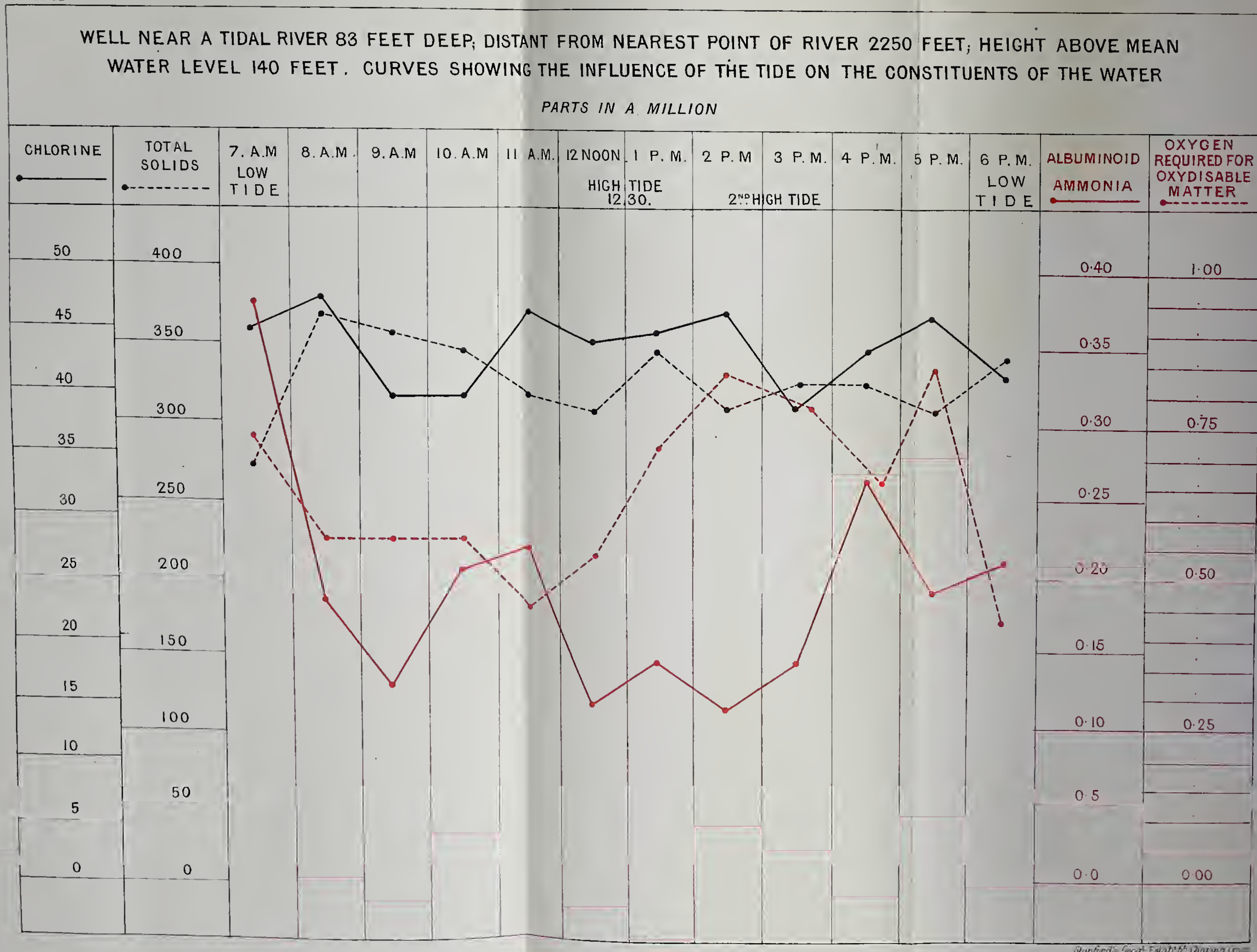
ranging between about 40 and 80 ounces in actua liquid, in addition to which he usually takes in about half as much again in the so-called solid food. An adult man in full health and vigour may be considered as requiring about 100 ounces altogether, 70 to 80 per cent. of which is taken as liquid and excreted as such by the kidneys, the remainder finding its exit through the lungs and skin. Cooking food takes at least a gallon, and personal washing 2 or 3 gallons, even without baths; a sponge bath requires from 2½ to 4 gallons at least; a general bath from 30 to 60 gallons. To this must be added the share of cleansing the house and utensils, washing the clothes, and the amount for water-closets. For these purposes we must allow about 11 or 12 gallons, 5 of which are required for water-closets. This would give in all (allowing a daily sponge bath) about 16 to 18 gallons per head. In the army the allowance is about 15 gallons, including water-closets—no extra amount being reckoned for women and children, so that the average allowance might be less than this by one-fifth. Where a regular system of sewers is in operation not less than 25 gallons per head ought to be supplied, otherwise it will be found difficult to keep them in good order. In cases where it is necessary to limit the supply, 4 gallons are the least a man can do with, and then there will not be real cleanliness. In some cases Dr. Parkes found that in the cottages of the poor, where the water was drawn from wells, only 2 to 4 gallons were used, but the inhabitants were not cleanly. The quantity used in the model lodging-

houses is about 7, and among the poor in the city of London, Dr. Letheby found 5 to be the average.

Under all circumstances a liberal supply of water is necessary, so that there shall be no bar on that score to personal cleanliness and frequent changes of clothing. Dr. Parkes states his belief that 'the remarkable cessation of spotted typhus among the cleanly and civilised nations is in part owing, not merely to better ventilation, but to more frequent and thorough washing of clothes.'

The Health of Towns Report, to which I have already referred, is filled with examples of the evil effects of a deficient supply of water to the poor, giving rise in many instances to dirty habits that would not have been fallen into had the means of cleansing been easily obtainable. Now, filthy persons and surroundings soon put an end to all self-respect, and the road to vice and misery is only too quickly trodden. It was shown also in evidence that, when opportunity offered, the poor gladly availed themselves of it, but that in too many instances the expenditure of time and labour was so great that it was barely possible for them to obtain what was necessary to support life. Add to this, that in many instances the water had to be paid for after all, and in Newcastle-on-Tyne, for instance, it was shown that the poor were paying, for a starvation supply of water, more than the better classes for a constant supply laid on to their houses. People complain of the poor being dirty, but I wonder how many of ourselves would take a tub of a morning if we had to stand for an hour or more at a

Table X



Stanford's Geog.l Estab.t Charing Cross

public pump waiting our turn to draw our canful! The diagram[1] shows the amount supplied in the metropolis and some other places.

Sources of water.—The question of the sources of water as regards quantity is a question for the engineer, but as regards quality it is one which we have to consider. Supplies from lakes and streams, if taken at a distance from habitations, are generally pure enough, as the Loch Katrine supply of Glasgow, the Itchen supply at Southampton, and some of the London supplies show. Supplies taken from tidal rivers, however, are often of a very different character. The effects of tidal water are also very important to the riparian population who draw their water from wells; and from the diagram[2] you may see the condition of a well near the Hamble River, in Hampshire. It is 83 feet deep, 140 feet above mean water level, and 2,240 feet from the nearest point of the river. On analysing the water on two different occasions I was surprised to find the results very discrepant, and learning that it was supposed to be affected by the tide I had samples drawn at different hours, and analysed them. You may see from the diagram how the constituents varied, the maximum and minimum evidently depending upon the tide. If sewage is poured into a stream it is not difficult to understand thus how it gets into the wells along the banks. Ordinary house-wells in the country, however, are more generally dependent for their impurity or contamination upon the contents of the neighbouring cesspools, and I have again and again had

[1] See Table IX. [2] See Table X.

to condemn the condition of a water and recommend the well to be pumped out, with the result of finding the cesspool emptying itself into the well. The danger is especially great in shallow wells above a stiff clay, for they drain the ground above the clay only; and frequently merely deepening them is sufficient to improve the water by getting the drainage of a wider area.[1] A deep well is advisable for many reasons: the water is cooler and generally purer, whilst if there be sources of contamination a greater stratum of soil will have to be passed through, with the probable effect of more complete destruction of the organic matter. Were it not for the purifying effects of the soil, I feel sure that excrementitious diseases would be much more common than they are, considering the way in which the dead well and the live well are too often placed lovingly side by side. Where water-butts are used, or where there is an intermittent supply in cisterns, the sources of contamination are numerous; sewer gases get in from the overflow pipe passing down to closet or drain; accumulations of dirt take place from neglect; rats, mice, cats, and such small deer fall in and putrefy, babies are sometimes put out of the way there, and even adults tired of life have more than once found there a congenial resting-place. Of course in the country, where houses are more or less isolated, storage

[1] A well at Netley Abbey, sunk to 20 feet, gave—

Total solids	148·75
Chlorides	86·80

When sunk to 30 feet it gave—

Total solids	16·8
Chlorides	6·5

of water is to a certain extent inevitable, but precautions to prevent contamination ought to be proportionately carefully taken, and consequently cisterns of wood or lead ought to be avoided, slate or cemented receptacles being greatly preferable—wood (unless charred on the inside) being apt to decay and favour putridity, and lead being easily acted upon by certain waters, particularly those containing the nitrogen acids which are far from uncommon. I have often found 20, 50, 100 milligrammes, and more, per litre, of nitric acid. Where the service pipe at a tap is of lead it is of less importance, as the water is in connection with it only a short time.

Legal enactments.—On looking over the existing enactments one is struck by the merely permissive character of most of them. The sanitary authority *may* supply water, or may make contracts for the same, but there is nothing to say that it *shall* see that a supply is provided. To this almost the sole exception I can find is that if it appears to the sanitary authority that a house (including thereby any building in which more than twenty persons are employed at one time) is without a proper supply of water, and that a supply of water can be furnished to it at a rate not exceeding twopence per week, the sanitary authority must give notice to the owner to take the necessary steps. The sanitary authority is also to take charge of all public pumps, conduits, &c., already existing, and may build others, for the gratuitous use of persons who carry the same away for their own use. Provisions are also made against pollution of the water supply by

sewage, bathing of men or animals, any dirty or improper water, gas-washings, &c. It is also provided that the urban sanitary authority may interfere in the case of any pump, well, or cistern they have reason to believe is polluted and injurious to health; but I do not find any provision of the same character for rural districts, where apparently the inhabitant is at liberty to swallow his own or his neighbour's sewage without any impertinent interference.

This legislation, in its extremely imperfect state, has *tumbled* up (like Mr. Pocket's children), the state having done absolutely nothing for the water supply of the people, and everything in that way having been left to private enterprise. Now water companies are but human, and as such liable to err, so that for years the supply has been far short of what it ought to have been. The Health of Towns Report has numerous passages of evidence showing the disadvantage to the community from the water supply being in private hands. How short-sighted has been the policy of our rulers, and how little have they understood the great duties that they owed to the people! Three-and-twenty centuries ago Plato laid down in his Republic regulations for water supply by the state; Herodotus mentions the care the authorities of the Greek cities took about their aqueducts and fountains; Aristotle is careful to recommend the utmost care about water supply, and the separation of the drinking-water from that used for other purposes, where it was not all equally good; whilst the enormous aqueducts of ancient Rome and her colonies, the great underground cisterns of Byzan-

tium, and even the later works at Malta and elsewhere all testify to the statesmanlike care for this important matter in many parts of the world. In India there are still remains of great works for water storage and distribution, and in Ceylon, Sir Emerson Tennent describes an artificial reservoir, a very sea, some forty miles in circuit, or one hundred and thirty square miles in extent. The truth is, our rulers have failed to perceive that this among other things ought to be a state duty. There is a little fear in this country of paternal legislation, probably from the doubt that it might lead to tyranny; but in a country where the legislation itself is done through and by the people this fear might, I think, be dismissed. At all events, the tyranny would not be greater than that of a water company that cuts off the supply of one of the prime necessities of life for non-payment of rates. The supply of water ought to be as free and copious to every one as that of air, and it ought to be the business of the state, either directly, or acting through local authority, but no community ought to be at the mercy of any private company. Water ought to be laid on to every house, and, if possible, to every floor; the supply ought to be continuous, so that no cisterns or house storage need be required. All water-rates upon occupiers ought to be abolished, and the cost included in the rent; but on no account ought water ever to be cut off. There ought to be a bath-room in every house, so that every one might have the opportunity of being clean. The purity of the water supply ought to be ascertained by constant analysis, as it is now in a great measure.

In rural districts more strict supervision of the condition of wells might very well be ordered, and stringent measures taken to enforce purity of water as far as possible. Doubts have sometimes been raised as to the possibility of getting an adequate amount of water to give a sufficient supply, but such a doubt in a country like this is preposterous. To supply the inhabitants of England proper, say 22,000,000, with fifty gallons a head per diem, would take half a cubic mile of water, less than one-fortieth of the rainfall of the kingdom, a proportion that with care could surely be secured for the purpose. Even the half of this amount, generally distributed, would be a material improvement upon existing conditions. At all events, we need not fear deficiency of supply if we only take care to keep pure what we do get; but there is no necessity why we should, in the words of the song, find 'meat and drink and physic too in plain cold water.' Let us hope that we may see the time ere long when the supply of water in purity and plenty shall be looked upon as the business of the state, a measure that would prove a great economy in the end. For if cleanliness be next to godliness (and considering the occasional style of the latter, the positions might be advantageously reversed) we may safely say, in the present day, that without cleanliness godliness has but little chance. We have happily separated the idea of sanctity from the idea of dirt, and, if we are to get to heaven at all, we shall have at least no worse chance with a clean skin.

LECTURE IV.

ON SOIL IN ITS RELATION TO HEALTH—REMOVAL OF EXCRETA AND EFFETE PRODUCTS—DISPOSAL OF THE DEAD—ENACTMENTS.

It has but rarely happened in the history of humanity that the site of a town or city has been chosen with regard to the healthiness of its soil; in the vast majority of cases other considerations have been the governing motives. Consequently, for the mass of the populace in civilised communities, the soil they have to dwell on has been selected for them, and they are practically debarred from any choice in the matter. Yet the question is one of very considerable moment, and the influence of soil is considered by some paramount as a factor in the propagation of disease. Even although we may hesitate to place it on the same level as air and water, yet we must admit its importance as affecting both more or less directly. The ways in which a soil may affect health are several, and they may be considered in certain divisions, as follows:—

1. The air in the soil.
2. The water in the soil.
3. The solid constituents.
4. The conformation, and the presence or absence of vegetation.

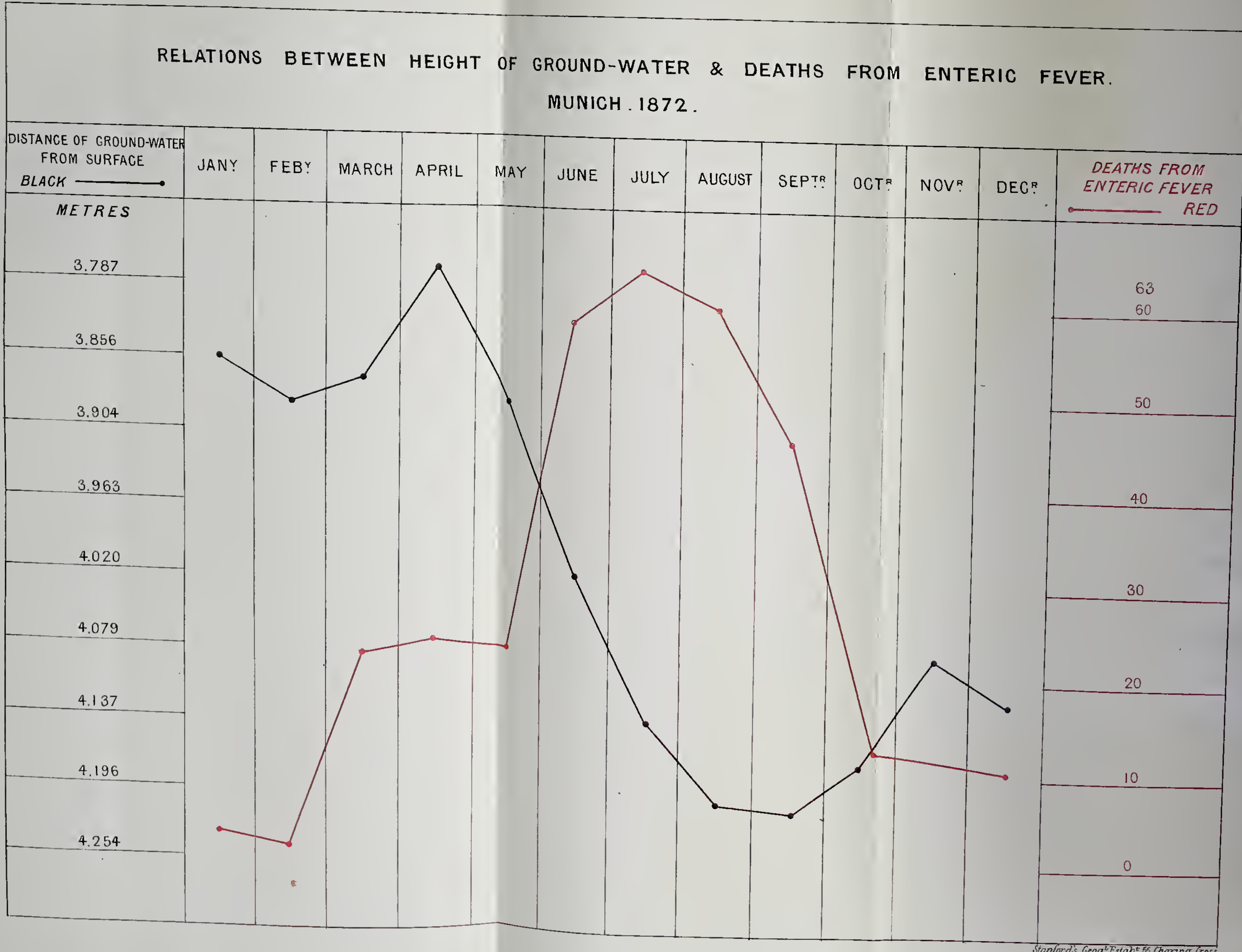
1. *Air in soil.*—All loose soils, and even most rocks, contain a certain amount of air, whose composition has been examined by different observers. As yet, however, the records are very imperfect. The chief condition is a remarkable excess of carbonic acid, due evidently to the oxidation of the organic matter in the soil, for it is found to vary inversely as the oxygen in the upper parts. The quantity is very variable, having been found by Boussingault as low as 2·4 per 1,000 volumes, and as high as 9·74, the latter in ground recently manured. This was at fifteen inches below the surface. Pettenkofer of Munich and Fleck of Dresden have both examined it at depths of from five to thirteen feet, finding more CO_2 in gravel than in sandy soil, reaching as much as 80 per 1,000. The maximum appeared to take place in the beginning of the autumn, apparently the accumulation of the results of the organic oxidation during the summer. Dr. Nichols of Massachusetts records his examination of the soil of the Back Bay lands at Boston, which are *made* land, consisting of gravel thrown on the mud, the ground-water being near the surface. He found a considerable amount of CO_2, but no sulphuretted hydrogen, and merely a trace of ammonia. In most cases there was an excess of oxygen over the proportion in atmospheric air. Pettenkofer has proposed to use the amount of CO_2 as a measure of the purity of ground-air, just as it is now of atmospheric air; and, in spite of certain objections, the suggestion is worth notice. Fodor, however, objects to this on account of the difficulty introduced by the mixture with

the atmospheric air. The total amount of air, or porosity of soils, is an important point, and it may be roughly estimated by Pettenkofer's method, viz. connecting two burettes by an indiarubber tube, fitted with a clamp, and filling one burette with the sample of soil, previously dried at 100° C., and the other with distilled water. On loosening the clamp, water will rise to the top of the soil until it forms a thin layer over it, and the quantity can then be read off and the proportion estimated. There is a general tendency to rapid oxidation of organic matter, especially in loose soils, and this is a valuable fact as regards health. Upon the porosity of the soil depends the ease with which gases find their way through it, and this becomes of much importance in towns, where the greater part is rubbish more or less impregnated with refuse organic matter. The mere fact of a house being built over any spot gives rise to a force of suction, from the air of the house being warmer; the air is consequently forced out of the soil into the house, to the detriment of the inmates. The distance to which emanations may be carried is considerable, my former colleague, Dr. Fyffe, having mentioned to me an instance in his own observation, where the foul air from a cesspool was sucked into a house a distance of twenty-seven feet. In other cases, of which I have examined and reported one myself, fatal poisoning by coal-gas has originated in this way. The diseases which have been chiefly attributed to soil emanations are (as stated by Dr. Parkes) paroxysmal fevers, enteric fever, yellow fever, bilious remittent fever, cholera and dysentery.

The knowledge of those dangers ought to convince us of the necessity of preventing the entrance of such emanations into our houses, by securing that their foundations shall be of cement or concrete, with a good layer of charcoal to intercept any that may by accident arise.

Water in soils.—The water in soils may be considered under two aspects, viz.: the *moisture* or dampness, and the *ground-water*, so called. The former is the amount of water existing in soil in contact with air and requiring heat or some other means to separate it; the latter, the *ground-water*, is the water continuous as such in the soil, in fact, the underground lake which exists at a varying depth in all places. This is the more important of the two; this water is continually in motion, generally towards the sea or the nearest watercourse; it is the source from which our wells are supplied, and its chemical constitution varies with the nature of the soil and the substances in and upon it. Its height in reference to the surface varies considerably with the conformation and character of the soil, the amount of rainfall, &c. The variation in height, which can be easily measured in wells, is considered by Pettenkofer and others to be the most important factor in the production of a large number of diseases. It is generally admitted that a persistently low ground-water, say fifteen feet down or more, is healthy; that a persistently high ground-water, less than five feet from the surface, is unhealthy; and that a fluctuating level, especially if the changes are sudden and violent, is very unhealthy. According to Pettenkofer, the most unhealthy time is the fall of

Table XI.

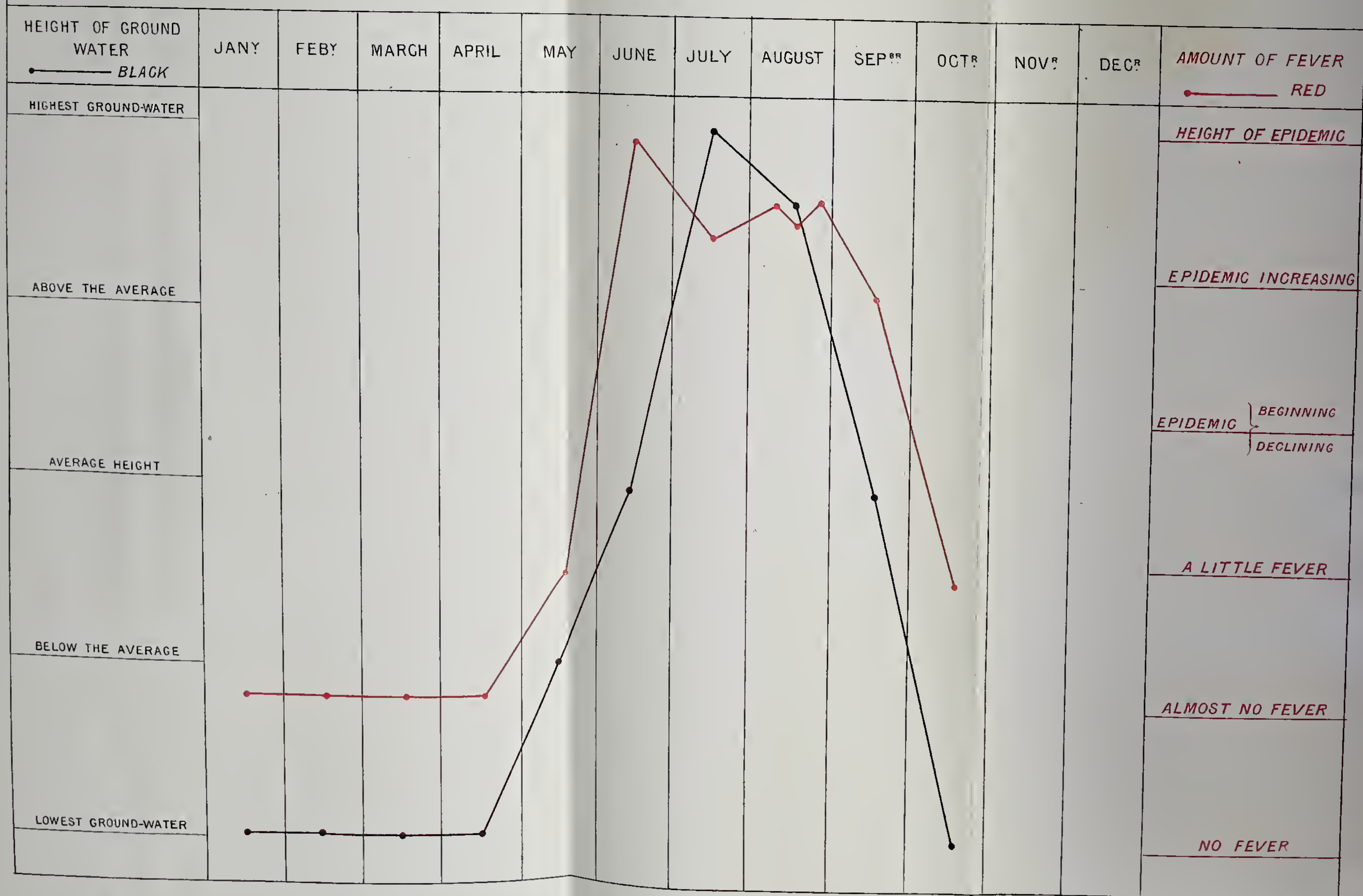


RELATIONS BETWEEN HEIGHT OF GROUND-WATER & DEATHS FROM ENTERIC FEVER.
MUNICH. 1872.
DISTANCE OF GROUND-WATER FROM SURFACE
BLACK
METRES
3.787
3.856
3.904
3.963
4.020
4.079
4.137
4.196
4.254
JANY
FEBY
MARCH
APRIL
MAY
JUNE
JULY
AUGUST
SEPTR
OCTR
NOVR
DECR
DEATHS FROM ENTERIC FEVER
RED
63
60
50
40
30
20
10
0
Stanford's, Geogl Estabt 55, Charing Cross

Table XII.

RELATION BETWEEN HEIGHT OF GROUND-WATER AND AMOUNT OF ENTERIC FEVER

ZÜRICH 1872.



Stanford's, Geog! Estab^t 55, Charing Cross

ground-water, and he gives curves showing the prevalence of typhoid in connection with the ground-water level at Munich for a number of years, which curves, as shown in his diagram, correspond in the main with his theory. The curves were submitted to mathematical calculation by Seidel, and it was found that the chances of their being connected with each other were 36,000 to 1. We may therefore accept, I think, as a fact that, in Munich[1] at least, the level of the ground-water is a factor in this disease. The view, however, is not borne out in other places, for in Zurich, for example, it is sometimes found to be directly opposed to Pettenkofer's view. This may be seen from the typhoid curve of 1872 in the diagram.[2] In the same way in 1867 the cholera curve at Zurich was not in accordance with the theory. On the other hand, the observations agreed with the theory in Berlin (where, however, the well-waters were very bad), and in Leipsic and Dresden in 1866. Numerous observations have been made in India, but the time has been too short yet to draw legitimate conclusions from them. As we have said, a permanently low ground-water is good, how great soever may be the dangers of a fall at the time. This is amply shown by the improvement in health in numbers of places, as given in an excellent *résumé* by Dr. Buchanan in the 9th and 10th Reports of the Medical Officer of the Privy Council. There it is shown that not only such diseases as typhoid fever and the like have been greatly diminished, but that even phthisis (including various destruc-

[1] See Table XI. [2] See Table XII.

tive forms of lung disease) has been much lessened. The proportion may be seen from the diagram.[1] And this has apparently been due to efficient draining of the subsoil and permanent lowering of the ground-water. Similar results have been recorded in America, particularly in Philadelphia, and in other places.

Solid constituents of the soil.—The solid constituents of the soil exercise a certain influence, partly due to their chemical constitution, and partly to their conformation. Some are inclined to attach considerable importance to the geological character as a factor, pointing out, for instance, that the cattle plague was limited by the Silurian strata. It would appear to be certain enough that this, like other diseases, was more severe in one soil than in another, but the difficulty is to eliminate other possible causes. For instance, in a recent report on the kingdom of Saxony, it is shown that, between 1832 and 1870, cholera has been worst in the coal-districts and bad in the diluvial; whilst the gneiss, granite, and sandstone had complete immunity. But in these last the drinking-water is always better than in the others,[2] so that, after all, the soil may have had only a secondary effect. Some effect has been attributed to the presence of iron (Sir Ranald Martin) as tending to cause malarious disease, and certainly in some very malarious districts the quantity of iron is considerable. The general consensus of observers, however, is to attribute malaria to vegetable rather than mineral agency.

Made soils.—I have already pointed out the danger

[1] See Table XIII. [2] See Table XV.

in towns from the fact of most of the soil being artificial, or *made* soil—that is, simply all sorts of rubbish thrown together; the usual preparation for building a street being to put up a notice, 'Rubbish may be shot here.' In Drs. Parkes and Sanderson's report on Liverpool, an analysis is given of the soil there, which is instructive as an example of the kind of stuff we locate our town population upon. The greater part was cinder refuse, but considerably mixed with other substances, such as potato-peelings, paper, wood, bones, rotten straw, rotten cloth, eggshells, fish-bones, &c. Detailed analyses show a considerable amount of nitrogenous organic matter, especially in those parts recently laid down. The authors of the report recommend that the ground on which such rubbish is laid ought to be drained thoroughly, so as to favour rapid drying, and that no building should be allowed upon it until two years after the last deposit.

Soils may be considered in relation to their power of absorbing heat. The table[1] shows the different degrees of this attributable to the composition of the soil, 100 being taken as the standard. It will be seen that sandy soils are the hottest, and the clay soils the coldest. On this point Dr. Parkes remarks —'In cold countries, therefore, the clayey soils are cold, and, as they are also damp, they favour the production of rheumatism and catarrhs; the sands are therefore the healthiest in this respect. In hot countries the sands are objectionable from their heat, unless they can be covered with grass. They sometimes radiate heat

[1] See Table XIV.

slowly, and therefore the air is hot over them night and day.' Heat is of course a powerful factor in the production of malaria, and in all probability also the poison of cholera, typhoid fever, and other diseases. The conformation of the ground, and the relation of the different strata are both of importance, as affecting the possibility of drainage, and the character of the water obtainable from wells. A town or village on a slight slope, for instance, or on an undulating site, will be healthier, other things being equal, than if built on a dead level. In the latter case, the difficulties in the way of drainage are considerable, and they are increased still more if the ground be of an impermeable character, such as a stiff clay. In that case organic impurities of all kinds collect more or less near the surface, being unable to penetrate into the soil. The water of the wells will be certainly impure unless they be sunk quite through such a stratum. Vegetation has a great effect in improving the healthiness of a soil, and it ought to be encouraged in all open places among or around habitations. In particular herbage is always good. The mere planting of a few trees is often sufficient to alter materially the healthiness of a place—as has been observed at Hong-Kong, and in the Landes in France, where the planting of the needle-shaped trees has been very successful in removing the malarious character of the soil; and in other places in consequence of planting the Eucalyptus or blue-gum of Australia. This last is likely to be extensively used in many places, as it is a valuable wood and a rapidly growing tree; indeed it would seem as if rapidity of growth

was to some extent a factor in this beneficial action of trees. The influence of cultivation on the health of a district is well seen in the improved condition of many parts of this country. In the days of Sydenham, ague was an extremely common disease; it is now confined to comparatively few districts, and is diminishing even there. The converse of the proposition may be seen in countries where tracts of land have been allowed to relapse into a wild condition, of which the Campagna of Rome is a notable instance.

Excreta.—From the consideration of the general question of soil we may conveniently pass to the particular cause of its most frequent impurity, viz. excreta of men or animals, the disposal of which has been the source of so much difficulty and so many mistakes. We have considered partially the effects of sewage upon health in speaking of water, and I referred to the matter in the lecture on air and ventilation, without, however, dwelling upon it in any detail. I will now say a few words upon the state of our knowledge as regards the effects of sewage emanations upon health. The diseases which have been attributed to this cause are the following: typhoid fever, diarrhœa, cholera, dysentery, pneumonia, ophthalmia, diphtheria, and probably also scarlet fever. Other diseases have besides been greatly aggravated by it, of which phthisis is perhaps the most important.

Typhoid or enteric fever.—That this depends to a large extent upon sewage emanations is proved by a good deal of evidence. Dr. Buchanan, for example, reports that a marked diminution of the disease has

uniformly followed improved sewage arrangements. In twenty-one English towns the average reduction of mortality from this cause was 45·4 per cent. In several cases the disease appeared to be confined to particular parts of a house exposed to the emanations of badly-trapped drains. This has been not unfrequently the case in some of the best houses, where the condition of the water supply was apparently unexceptionable. In imperfectly-ventilated drains the tension of the gas in the drain is always greater than in the house, and consequently it tends to force its way up the soil-pipes, and in this way we may account for the apparent anomaly of the houses in the upper part of a town suffering more sometimes than those in the lower. Dr. Haviland puts the case very tersely when he says that the poor take this disease through water, the rich through air. An unequivocal case of communication of disease is given by Riecke,[1] where two men were attacked in consequence of the effluvia from the stools of a typhoid patient placed under the unceiled floor of their sleeping-room. At the same time it appears certain that all sewage emanations do not produce enteric fever, as they are frequently breathed by persons with apparent immunity. *Diarrhœa* is a very common result of sewage air, and appears particularly to attack children. It is not unfrequently accompanied with pyrexial symptoms. *Cholera* has been traced to sewer air, and in two cases that occurred under my own observation at Parkhurst, in 1854, the proximate cause seemed to be the clearing out of an old latrine. At

[1] Parkes, p. 123.

the same time there was cholera in the country at the time, although communication could not be definitely traced. *Dysentery* has also been undoubtedly traced to this cause. *Pneumonia* as a result of sewer air is now distinctly recognised, and the remarkable case in the school at East Sheen must be in the recollection of all. With regard to *Ophthalmia*, I have seen it arise in a company of my former regiment at Malta, apparently in consequence of foul air arising from a ditch below the barrack-room window, into which ditch the sewage of the fort passed. Removal of the men to another part of the barracks effectually stopped it. When the regiment also was quartered in Fort Ricasoli the drains were in very bad order, in fact they rather ran uphill than otherwise. A party was told off daily to flush them, and during the time the corps occupied the fort the men were perfectly healthy. Subsequently another corps occupied the same place, but I believe without taking the same precautions; the result was such severe and extensive ophthalmia as to necessitate its removal. *Diphtheria* has been most certainly traced to sewage air, and with this curious concomitant fact, that in some cases the introduction of improved drainage has been followed by an increase of the disease. Whether this is due to improved diagnosis—to the communication of the poison through the drains, or to the mere stirring up of the fæcal deposits, it is difficult to say. But it would certainly seem as if the disease was capable of being generated by any sewage whatsoever, placed under particular conditions. A case in point was mentioned to me by my colleague, Pro-

fessor Maclean. A gentleman had built a new house, fitted as he believed with all the best and completes sanitary appliances. He had not been many months in it when his children were struck down with diphtheria, which proved fatal in one case. He consulted Professor Maclean on the matter, and he unhesitatingly pointed to some defects in the drainage arrangements as the cause. The gentleman said that was impossible, as the house was a new one, never occupied by any but his own family, and that no expense had been spared to make it perfect. However, he complied with Dr. Maclean's recommendation, and had the soil-pipes examined, with the result of discovering that one had been unsecured at a bend, and that for months a leakage had been going on at a point immediately below the nurseries of his children. The evil had been intensified by part of the warming apparatus passing near this, and so aiding the ascent of the mephitic poison.[1] I do not know that *scarlet fever* has been positively traced to sewer air, although there seems to be some evidence on the point, but I have certainly seen pyrexial attacks of a modified kind, accompanied with intense redness of the tongue and fauces, which were distinctly traceable to this cause, being confined to persons in a house who were specially exposed to it, and not affecting other inmates who had not been so exposed.

[1] A similar case has since been mentioned to me by Dr. Frank, as having occurred at Cannes in France. In that case a ventilating pipe from a drain passed up close to a cupboard in a nursery; it was made of glazed tiles, and some of the mortar had given way, allowing the sewer gas to escape into the nursery, with the result of all the children being struck down by diphtheria.

That other conditions are produced, such as anæmia, dyspepsia, &c., is admitted, and it would seem that all diseases, such as ulcers, erysipelas, and especially venereal disorders are severely aggravated by sewer emanations. It would, however, appear as if some confinement, and probably a certain temperature, were necessary to make sewage especially hurtful — for when freely exposed to air, as when thrown on the land, it is certainly much less hurtful, although some evidence exists that warrants disease being occasionally tracked to that source. In the irrigated meadows near Edinburgh, where the plan of disposing of the sewage has been carried on for a couple of centuries, no very marked disease has been traced, although a good many persons live within reach of its decidedly foul odours.

Whatever view we may take of the *modus operandi* of sewage as a poison, it is certain that we must get rid of it by some means or other, and not permit its accumulation in the neighbourhood of our habitations. In former times, when the example of Imperial Rome had been forgotten, when drainage was not, and every man did that which was right in his own eyes, the cesspool was the only method of disposal, when any was provided at all, and the night-cart was the only semblance of a sanitary measure. In many places even this was almost considered a work of supererogation, and filth was allowed to accumulate in the streets until the rain washed it away. In the country the provision of any special place of retirement seems hardly ever to have been thought of, and in my own recollection this has existed. I remember, for instance,

as a boy spending my school holidays at a farm-house one year, where, on my asking about the water-closet or privy arrangements, great surprise was expressed at the idea of such a thing; they had nothing of the sort, they said, and men and women appeared simply to resort to the fields or the midden steading as necessity required.[1] I do not know whether this style of thing still exists, but it is not improbable in many parts. I know that it is not very long ago since a similar condition of matters presented itself to a friend of mine, who was paying a visit of business to a farmer in a somewhat remote district. He urged him to have a place built, and accordingly at his next visit the farmer told him with some pride that he had acted upon his suggestion, pointing at the same time to an erection, quite unprovided with a door, immediately facing the front of the house! The condition of towns as regards sewage arrangements, which was revealed by the Health of Towns Report, was extremely bad, and to some of them I referred in the first lecture. I may just refer to a few of the notes recorded at the time. In Birmingham we find 'courts full of privies, open, with a sad stench,' 'bad water—water as green as a leek;' in Wednesbury 'filthy open privies, and stagnant liquid filth;' in Bilston 'open privies, open drains under houses, stench dreadful—

[1] The love of old institutions was beautifully exemplified in the case of a farmer whose landlord, desirous of improving the sanitary condition of the house, had caused the old midden to be removed and a flower garden substituted. When the flowers were in full bloom, he asked the farmer if it was not a great improvement. 'Ou aye,' replied the farmer, 'the flowers is a' vera weel, but we miss the auld midden whiles tae!'

"enough," said the women, "to bring plague among poor folks;"' in Wolverhampton 'privies terrible.' With regard to this last place, a former inhabitant told me a few years ago that there the *petty* was always in the cellar, so that the condition of the rest of the house may be left to the imagination. In the pottery towns the descriptions are wonderful: Burslem has a 'filthy open mud-hole, near old church, receiving sewers and filth in a populous neighbourhood for manure;' in Newcastle-under-Lyme 'the filthy open privies run over into the street, the refuse from the houses is flung into one promiscuous heap contiguous to each property, and removed when it is incapable of receiving more.' In Shrewsbury (as a sample of another class of town) the drains pass under the passages of the house; 'smells dreadful,' say women near; 'cannot live in the house for the smell, worse than a privy.' In the meantime it is recorded that the authorities *never* cleanse the courts or small streets. Perhaps the best idea of the state of affairs may be gathered from a short abstract given by the commissioners with reference to the condition of fifty-one of the principal towns visited, where the annual mortality on an average was the highest. They report as follows:—

	Good.	Indifferent.	Bad.
Sewerage . . .	1	7	43
Cleansing . . .	2	7	42
Supply of water . .	6	13	32

'Powers generally insufficient and frequently neglected.

'These towns comprise the seats of all the chief manufactures of the kingdom, together with the four principal seaports (after London), and contain a population exceeding three millions of persons.'

It cannot but be a matter of rejoicing that such conditions are for the most part things of the past, although much remains to be done. It must, however, be admitted that in rural districts things are still in a very bad state, the cesspool being almost universal, and in most cases constructed of porous material (where it is not a mere hole), purposely to allow of soakage into the soil to save the expense of repeated emptying. The consequence is that one case of enteric fever has the best possible chance of becoming the focus of an epidemic, as has been seen at Terling, Over Darwen, and elsewhere.

Modes of removal.—When we come to consider the modes of removal, we find the question in a very whirl of controversy, which rather reminds us of Milton's description of chaos:—

> For *hot, cold, moist,* and *dry,* four champions fierce
> Strive here for mastery.

The plans for removal may be divided generally into wet and dry, setting aside cesspools, already referred to. Of the wet methods, we have the arrangements of water-closets or trough-closets, differing in points of detail, but having in common the principle of water-removal. The subsequent disposal consists either in discharging the whole material into the sea or river, or in removing the solids by some special process and discharging the liquids either into sea or stream or over land.

It would be obviously impossible to discuss the various plans in detail, but we may briefly notice a few of the chief points for consideration. In the first place, it is now admitted that the method of discharging all our material into the sea is a mistake; it may go to feed the fishes, but it is a questionable way of doing so. Besides we know, from what we understand of the circulation of matter that the effete matter of animal life is most easily and effectually dealt with through the agency of vegetable. Although this has been known in a dim kind of way for many ages, it has, in the anxiety to be rid of a present nuisance, been up to the present time very generally neglected. And whilst, on the one hand, the fertility of the country and the teeming population of China have been largely attributed to the care with which they have returned to the soil what had been taken from it, the barrenness and national decay of other once famous nations has been debited to a neglect of such duties. Water, nevertheless, is so convenient a method of removal in large communities that it has been almost everywhere resorted to, even at the double cost of wasting valuable material, and purchasing elsewhere still more expensive substitutes to take its place. Now, however, that such questions are more generally understood, the water itself, so apparently helpful, is found to present the greatest possible obstacle to improvement; and it is still a doubtful matter if the application of sewage to land on a great scale can really pay, when the difficulty caused by the mass of water is considered. The question is, however, likely to be

solved ere long, as, besides the cases already in existence, others are on the point of being tried—at Wimbledon, for instance, where the sewage is about to be spread over a farm of some extent; and, on a gigantic scale, at Berlin, where the whole excreta of the city is to be dealt with in that way. In a hygienic point of view the questions are these. 1. Is the material effectually removed from our habitations? 2. Is there danger to health from its application to land? 3. Is there danger to our water supply by the flow of liquid matter into our streams? 4. Are there other dangers incidental to the plan?

1. There can be no doubt that, where the situation is favourable, and the water plenty, the material is effectually removed. 2. In spite of some statements, there is no evidence that there is danger to health from its application to land, either directly or through the crops yielded. 3. The pouring of the entire sewage into streams, or even into the sea, is attended with danger, and is certainly a most abominable nuisance at all times, as the former condition of the Thames, the existing condition of the Clyde, and above all the odours of the sweet-smelling Liffey most abundantly testify. But the question of the disposal of the effluent water, after separation of the solid sewage, is a less easy matter to determine. The effluent water is often very pure, at least to all appearance, and it is said to be constantly drunk by the working people at Merthyr Tydfil. Professor Frankland proposed a standard of purity, which, however, was not definitively adopted, and he showed

conclusively that it was impossible to allow any considerable amount of organic matter, trusting to the oxidation of it on its passage. Recently a question arose about the sewage of Winchester, the effluent water of which was to be discharged into the Itchen River, which supplies in part the water for Southampton. The sanitary authority in the latter place was asked what degree of purity they would demand, and Dr. Parkes, to whom the question was submitted, suggested that the water should be required to be not less pure than the average supply of Winchester itself, with the exception of some slight increase in mineral matters and the nitrogen acids. This, I think, is a fair standard, as it keeps out really noxious matters, and at the same time allows sufficient room for the inevitable products of oxidation.

4. With regard to the other dangers incidental to water-carriage, the chief is the reflux of sewer gas into houses, to which reference has been already made. This danger, taken in connection with the pollution of our streams, has not unfrequently raised the doubt whether water-carriage has not produced more evils than it has cured. Certainly, where sewers are untrapped and unventilated, and drains are made of porous earthenware, or of glazed clay improperly cemented, much evil may and does arise, but this is less chargeable upon the system itself than upon the neglect (or worse) of those charged with carrying it out. But where drains are honestly made and not scamped, where they are properly cemented and ventilated, where overflow pipes of

cisterns are disconnected from drains, where stools of infectious cases are carefully disinfected before passing into the drains, and where the construction is good and the water supply sufficient, there is no reason why water-carriage should not be perfectly healthy. It is true that the postulates are numerous, but so they are in other methods, and it must be besides borne in mind that a system of drainage is necessary for the removal of watery slops, even unconnected with sewage, so that the constant existence of a drainage system for this purpose will always present an easy method of disposing of the sewage also. Were it impossible to ensure the above postulates, and were the health of the community positively deteriorating in consequence of sewer poison, then there would be no alternative except to prohibit the passage of sewage matter into the drains at all, and the provision, under compulsion, of some other method of removal, the possibility of which we may now briefly consider.

Of the dry methods of carriage there are various kinds—such as the well known earth-closets of Moule, and the plans of Taylor, Turner, Moser, and others, in which ashes or charcoal are used. In Moule's plan both urine and fæces are received together, but in the others a separation is made, more or less completely. There is, besides, the system of Goux, which has worked extremely well at Aldershot and elsewhere; this consists in receiving the excreta into a bed of dry fibrous material, such as straw, horse-litter, or the like, to which is added a small quantity

of a deodorant, such as sulphate of iron. In all cases the ultimate destination of the material is the soil, for agricultural purposes, and, where the land is not too far distant to make the application of it unprofitable, any or all of those methods seem to do well. The use of a dry method, however, in a large community, such as a town, is rendered difficult on account of the expense of labour for the ultimate removal of the material. On this account the pneumatic method of Liernur seems to commend itself to public attention. It has been tried at the Hague, at Amsterdam, and at Leyden, in the country of the inventor, and also at Prague and in some other parts of Germany, as a partial experiment. It has been variously reported upon, but appears to be growing in favour, on the whole, and is, I believe, about to be applied on a large scale in the city of St. Petersburg. It is also under consideration in this country, under the auspices of Mr. Adam Scott, and it is at present being spoken of as a probable solution of the difficulties of Winchester in the disposal of its sewage.

Theoretically the plan is extremely ingenious, and it would doubtless be a great success if the practical working answered the expectations of the inventor. The advantages claimed for it are these: no reflux of sewer gas is possible; no pollution of our water supply is possible; no leakage of pipes or pollution of our soil is possible; the more fastidious may still enjoy, at a slightly-increased expense, the luxury of water-closets, if they please; no part of the material is

lost, and nothing is added to it to dilute or diminish its value as a manure. Add to these considerations the fact that, after the works are laid, the working expenses are comparatively small, and the profits large and certain. It may besides be applied to a large or a small community, or even to a section of a community, if required. We cannot as yet pronounce upon the practical working of the scheme, but it seems feasible, and if it is really calculated to accomplish all it proposes it would pay the country well to apply it everywhere, even if it cost us a sum greater than a war indemnity.

Legislation. — The legislation on the subject of drainage, and removal of refuse and effete matters generally, is of what we may call a *patchy* character; and, in the present condition of doubt in which the question stands, this need not be wondered at. That all refuse, excreta or otherwise, ought to be removed from the neighbourhood of our dwellings, is admitted, but the method of doing so cheaply and effectually is still being sought for. It has been tersely said, 'the sewage to the land, the water to the sea;' and to this I would desire to add, 'the rubbish to the fire.' Could we accomplish this, what should we not gain, both in health and lucre? Although it is not an easy task to say how far the legislature should interfere in this matter, it is certain that much more ought to be done than is at present done. In many towns cesspools still exist, and in rural districts they are general—in both cases sad nuisances. Almost any method is better than this, and if cesspools could be abolished out of the land

a great point would be gained. Dr. Parkes thinks that no single system will meet all cases, but that, on the whole, where circumstances are favourable, water-carriage is the best for large communities. With our present knowledge, this is probably the conclusion which would be most generally arrived at; but I would add that, if Liernur's system really accomplishes all it proposes, the question is immediately solved in another direction, and we should only have to provide for the removal of water, charged more or less with comparitively innocuous substances.

Disposal of the dead.—From the removal of the substances which, by the exercise of our vital functions, we render effete in and around us, it is an easy transition to consider the removal of ourselves when we become effete in our turn. It is a singular satire on the vanity of life to think that, no sooner is the breath out of our bodies, than we become a nuisance, even to our nearest and dearest, and that the chief question is how to put us most effectually out of the way. That this must be done admits of no question—the only doubt is as to how it had best be done for the good of the community. Hitherto, in modern times at least, burial in the earth has been most constantly resorted to, as being on the whole the easiest and the cheapest. The condition to which old burial-grounds, in the midst of crowded populations, had been brought is well shown in the report on extra-mural sepulture, published in 1850. The movement in this matter, which ultimately led to legislation, is largely due to Mr. Edwin Chadwick. It was there shown that, in the

metropolis, on spaces of ground not exceeding, in all, 218 acres, closely surrounded by the abodes of the living, crowded together in dense masses, upwards of 50,000 dead bodies were buried every year. In Bethnal Green, in about $2\frac{1}{2}$ acres, upwards of 500 bodies were buried every year, for 100 years; in Bunhill Fields, in less than 4 acres, about 1,000 annually for 140 years; and in St. Pancras, which did not exceed 4 acres, the remains of twenty generations lay, whilst, even after it was considered full to excess in 1830, 26,000 bodies were interred there in the succeeding twenty years. Altogether it was estimated that into the 218 acres already mentioned there were a million and a half of dead bodies crammed in every thirty years. In St. Ann's, Blackfriars, the gravedigger could only find a spot for a grave by boring for it, and this seemed to be the rule rather than the exception. I mention these facts to show what we have left behind, at least in large towns, but the matter is still one that requires legislation in many places. From the increasing population, it is becoming daily more difficult to dispose of the dead, and the question has recently been discussed with much enthusiasm on the various sides. The older methods of burying in vaults, bricked graves, and in slowly-perishing coffins can hardly be defended; and the choice seems to be between burial in the earth so as to ensure rapid decay, committal to the ocean, or cremation. The first has been strongly advocated by Mr. Seymour Haden; the second is recommended by Dr. Parkes; whilst the third has found various supporters, including Sir Henry Thompson, Sir Charles Dilke,

and others. The burial in the earth in perishable envelopes has been urged by Mr. Seymour Haden with really idyllic eloquence, and he has claimed for it that it is the natural and proper method of disposing of the elements of which our frames are composed. Why it should be more so than cremation I fail, however, to see, for the latter restores carbonic acid to the air, as well as ammonia, and these are the great food of plants, whilst the salts can go to the soil and so nourish the crops for other generations. The burial at sea may have advantages, but there are also disadvantages, and I do not think that it is likely to be generally adopted. For my own part, I think cremation the best and the most effectual method, carried out, as it would of course be, in a complete and perfect manner. In countries where burning is resorted to, it is a horrible and disgusting nuisance; but then the burning is of a most imperfect kind, and does little more in many instances than intensify the horrors of putrefaction. But in cremation, as proposed, there is nothing to offend the senses or the feelings, whilst we unquestionably get rid of all nuisance for ever. I am inclined to think that this is the plan that will be adopted in the future, with, it may be, certain modifications. Under any circumstances, it will become the duty of the state to enforce here, as in the question of other effete matters, that method of removal which shall prove to be productive of the least nuisance. 'Thanks to the ignorance of our forefathers, we now enjoy an impure soil—let us see that posterity does not say the same of us.' [1]

[1] Dr. Wolff of Erfurt.

LECTURE V.

FOOD AND BEVERAGES—RELATION OF FOOD TO WORK—EXERCISE—LIMITATION OF WORK BY THE INTERFERENCE OF THE STATE IN RELATION TO AGE, SEX, ETC.

THE subject of Food, to which I now propose to direct attention, differs in some degree from the questions previously treated of. In the case of air or water, we had to deal with the difficulty of getting either pure or in sufficient quantity, but the purity or impurity in each instance depended, we saw, upon causes which acted indirectly: that is, they were the consequences of ignorance or neglect, for the most part, but not of direct and wilful sophistication. No man, for instance, wilfully vitiates the air or the water as a direct matter of profit, although he may, by neglecting to provide means of ventilation, or by allowing impurities to pass into watercourses, accomplish both evils, and effectually undermine the health or even take the life of his neighbour.

But in the case of food it is wholly different, for we have to contend against, not only ordinary causes of unwholesomeness, but also such wilful falsification as the vendor may find it for his advantage to practise. Again, as food is to the body as the fuel to a steam-engine, we have to consider its productive cha-

racter as a source of force; for although, as in the case of the steam-engine, such force could not be manifested without water and air, its measure is generally taken from the expenditure of the food or fuel, rather than from the consumption of air and water, which it would be so much more difficult to deal with. We have, therefore, three main aspects under which to view food (including therein beverages), namely :—

1. Its wholesomeness and soundness, as regards freedom from putrefactive change, decay, deterioration, or introduction of noxious substances, such as parasitic ova, and the like, or from accidental admixture of other substances.

2. Its purity, as regards freedom from adulteration practised intentionally for purposes of gain, such adulteration consisting, either of the addition of other substances more or less noxious, the abstraction of one or more of the normal constituents of an article, or the mere dilution or lowering of the strength of an article.

3. Its value in a dietetic sense, and the measure of productive work which can be got out of it. In relation to this last division, come the questions of how much work or how much exercise ought to be required of an individual under his particular circumstances.

Wholesomeness and soundness of food.—Let us consider, first, the wholesomeness and soundness of food. The enactments existing on this point are almost entirely directed towards articles of a perishable nature, such as meat, fish, poultry, game, or vegetables;

also fruit, corn, bread, flour, and milk. Power is given to the inspectors to seize such articles if they appear to be in an unwholesome condition and unfit for the food of man. This may arise either from decay having set in, or from the animal having been diseased. In both cases the provision is a most salutary one, although logically we might find some difficulty in drawing a hard and fast line in this matter. While few would hesitate to say that *high* beef or mutton was unwholesome, the majority of people eat venison in a similar condition, not only without scruple, but with relish. Few things are more unpleasant than poultry that lacks freshness; yet we serve up our grouse and other game sometimes in a most animated condition. In the same way we eat mouldy cheese, the Chinaman swallows bad eggs, some races like putrid fish, the Indian disputes a foul carcase with the prairie dog. Even in the matter of oysters, which one associates with special ideas of freshness, it is sometimes a question of taste. It is stated, for instance, of the first monarch of the house of Hanover, that he objected to the English natives, as being wanting in flavour. At last a shrewd courtier privately recommended that the generous molluscs should be allowed to die before being brought to the royal table. The king at once recognised the familiar flavour that had been so grateful to him at Herrenhausen, and directed that he should always be supplied for the future from that particular bed. That the eating of meat of any kind in a state of decomposition is unsafe, may be stated as a general principle, which is supported by particular instances, but that it

is always followed by bad consequences could not be said with due regard to fact. It is quite possible that, in the cases where taste or fashion prompt the practice, bad consequences may be averted, partly by cooking, and partly by the fact that only a small quantity of it is eaten generally. On the whole, the probability is that it is a question of degree, the mere tenderness of meat, which makes all the difference between an enjoyable meal and a struggle for life, being itself but the earliest stage in the journey towards decomposition. It is, therefore, a question which has to be decided more on principles of common sense and experience than upon any definite line of limitation which science can as yet lay down. It becomes a different matter, however, when the animal has been diseased, at least when it has become the breeding-ground of some parasite, such as the cysticercus or the dreaded trichina. This is a case where science steps in, and unhesitatingly pronounces judgment. Similarly, flour may become the home of acari, or the congenial soil of puccinia and other fungi, all of which are readily detectable by means of the microscope. No evil has been positively traced to eating diseased meat, if thoroughly cooked, but it is, of course, to be avoided if possible. To go much into detail on this point would be obviously out of place, but we may say that, on the whole, fair provision is made by the legislature for dealing with this important question. The existing powers, however, require extending, to include all articles of food whatsoever, and not merely those mentioned in the schedule.

Adulteration.—The question of adulteration is one, however, of greater difficulty, for its detection is more difficult, requires more scientific knowledge, and, above all, strikes at even more interests. The falsification of articles of commerce has probably been practised at all times, and is no less an abomination than the false balance denounced by Solomon ; but it is only in recent times that it has risen to the dignity of a fine art. Fortunately, however, honest science never lags far behind, and though she may be occasionally baffled for a time, she never knows what it is to be beaten, and sooner or later turns the flank of her adversary.

The difficulties that stand in the way of dealing with adulteration are mainly two, viz.: 1. The discrepancies of opinion among analysts and experts; and, 2. The reluctance of the legislature to grant sufficient powers. Now, with regard to the first, I would remark that, although there have been discrepancies, they have been on the whole comparatively few, whilst they have of course been made the most of by interested parties. Again, the analysis of food and beverages has not hitherto been extensively practised—in fact there was no field for it, and the work was done by chemists here and there, more as incidental to other enquiries than for a direct object. It is, therefore, I think, a matter of congratulation rather than otherwise that so many men of fair competence have been found for the work. As the field enlarges, so will the skill and experience of the workers, and I am sure that we may venture to warn the adulterating gentry, even the *dodgiest* of them, that their day is rapidly drawing to an end.

The second difficulty is the reluctance of the legislature to grant sufficient powers. This is shown both in permitting by enactment the introduction of extraneous substances, and also by placing the *onus probandi* upon the public, in so far as proving that the adulteration was *knowingly* practised or acquiesced in by the vendor. The former is of comparatively little importance, as it is confined to few articles, and will probably be got rid of; but the latter is a most serious stumbling-block, and, if allowed to remain on the statute book, will greatly hamper if not nullify completely the operation of the Acts. It is the old maxim, *caveat emptor*, in its most dangerous form. It seems to me that in commercial matters there is such a lax morality that nothing but a stringent law ought to be passed if we are to have one at all, and that the motto ought to be *caveat venditor.* It seems to me so clearly the duty of a tradesman to see that his wares are pure, that I cannot understand that it should be a matter of question at all. It has been sometimes urged that the law ought not to be made too strict, because it might bring embarrassment if not ruin upon a number of people. An argument of this sort, to be worth anything, ought to be of general application, so that, on the same principle, we ought not to lay hands too suddenly upon Bill Sykes or the Artful Dodger, but let them go on in their own peculiar line for a time, until they can accommodate themselves to a change of circumstances. Adulteration is just as much an act of theft as picking a pocket, only it is done more persistently and with the addition of hypocrisy; were it treated in the same

way as theft we should soon have no more of it. In the meantime, if penalties that do exist are made to fall smartly on the retailer, he will find his remedy (if he be honest) by proceeding against the wholesale dealer, and so on, until John Chinaman, for instance, no longer finds a market for his *lie-tea* and other rubbish, when he will give up compounding them, and may turn, if not to some honester occupation, at least to a form of villany that will affect us less directly. However plausible may be the plea for letting men down softly, nothing is really more dangerous in many cases for the community. As a case in point, I may call attention to the Act for introducing imperial measure into this country. At that time it was intended to be of general application, but, on the representation of the wine trade that a great quantity of valuable stock was bottled in the old measures and that rebottling would entail great loss, the law was so far relaxed as to allow of the stock being sold as it was. What has been the consequence? Half a century has passed, and we are still, as regards bottled liquors, as far from having imperial measure now as we were then. In particular the foreign bottles are becoming fine by degrees and beautifully less; a claret bottle, which ought to contain 76 centilitres, now barely yields 70, and as for brandy, it will soon be difficult to pack an imperial pint into a reputed quart. It is quite plain that had all measures, except the imperial been definitively abolished at a specified time, people would now know how much they ought to get when they ask for a bottle of wine. Similarly, if adulteration be not dealt with in a definite

and stringent manner, it will go on practically for ever. But the interest of the trading community is very powerful, as may be seen by the lax way in which the law is administered in cases of false weights and measures. The use of such weights and measures is one of the cruellest forms of robbery, bearing as it does upon the poorest and most helpless of the community. Yet so venial is the crime considered that it is often punished with the most trifling fine; whilst it is not long ago that a member for a metropolitan borough was jeered at and hooted for expressing himself with honest indignation against the practice. In this and in the treatment of adulteration we have much to learn, and might profitably take a lesson from other countries.

In matters of food analysis and in the crusade against adulteration, the name of Dr. Hassall stands prominently forward; and there can be little doubt that the extensive researches undertaken by him as the commissioner of the 'Lancet,' and subsequently, have largely contributed not only to our present knowledge, but also to the carrying out of the legislation on the question, such as it is. At the time he began his enquiry adulteration seems to have been very general, as a reference to the 'Lancet' of twenty-five years ago will show. Indeed an eloquent friend of mine remarked that, even in the matter of pepper, there was not enough of the genuine article to be found in London to provoke a sneeze! Since that time a very decided and wholesome change has taken place, and although, I doubt not, even pepper has still its integrity tampered with

we might confidently trust to getting enough of the genuine article for sternutatory purposes. In the present day, however, adulteration is said to be on the whole limited to comparatively few articles, but these, on the other hand, are of large and constant consumption. The chief are—milk, butter, tea, coffee, cocoa, mustard (and probably other condiments), beer, wine and spirits, to which we must add bread, in so far as the addition of alum is concerned. Sugar is now so cheap that it appears to be rarely tampered with. Although the list is not a long one, yet, as I have said, it includes some of the chief articles of daily consumption, and especially those which are in many cases the *sole* food of the poorest classes. The importance of checking any sophistication of them is therefore manifest. Fortunately, to an analyst of decent acquirements and average caution, none of the cases present any formidable difficulty, except those of butter and the alum in bread. Recent observations, however, appear to be clearing up some hitherto dubious points, and in particular the Society of Public Analysts is doing good work in this direction. There is one consolation that, on the whole, adulteration, as now carried on, is limited to dilution of articles, and seldom adds noxious substances. Thus milk suffers from two forms of sophistication—abstraction of cream and addition of water, which two processes are very convenient for the dishonest tradesman, the one balancing the other, so that if we trusted to specific gravity alone we should be completely baffled. Thus a sample of milk, of original specific gravity 1030, may have a third or a

half of its cream removed, and its specific gravity raised in consequence to 1036. But we know that every ten per cent. of water added lowers specific gravity three degrees, so that we have only to add twenty per cent. of water and the specific gravity falls to the original 1030. When, however, the analyst steps in he finds all the constituents lower than normal, especially the lactin and casein, or what Mr. Wanklyn calls the solids not fat; he has therefore no difficulty in saying that such and such tampering has taken place. For practical purposes the knowledge of the specific gravity and the amount of cream (in hundredths by measure), or the amount of fat by Vogel's method, will enable us to say if milk has been tampered with or not, without much danger of serious error. Very few authentic cases are reported now-a-days in which anything else than water is added to milk. In the case of tea, although a good deal of filth in the shape of *lie-tea* finds its way into the cheapest kinds, in the majority of cases the sole sophistication is the use of leaves that have been partially exhausted and redried. This pays better and is much easier than using the leaves of other plants. It has even been said that contracts have been entered into for buying up tea-leaves that have done duty in the sweeping of floors—a horrible notion! Fortunately the detection in such a case is pretty easy. By determining the amount of extract yielded to water and the amount of ash, it is quite in our power to declare whether tea has been used already or not. Beyond this, however, chemistry can hardly go far as yet, and to distinguish a fine from a common tea the

delicate palate of the tea-taster or the connoisseur is of more value than the appliances of the laboratory. The recent comparatively active movement against adulteration has had some effect on the character of the tea market—green tea, for instance, having been greatly diminished in quantity, with the near prospect of its disappearing entirely. This may be regretted by a few, but on the whole it will be for the general good, as it will reduce by at least one the number of imported articles *known* to be adulterated. An English officer, who was present in the last China war, described to me the making of green tea for the English market, as seen by himself. It being war-time the troops were not particular where they went, so he effected an entry into an establishment where he was certainly not expected. On enquiring what was going on he was told it was *English Pigeon*, so he demanded that the 'pigeon' should be proceeded with. The process consisted in a Chinaman taking up some Prussian blue or indigo, probably mixed with fine clay, and rubbing it over his arms (which were moist from natural exudations); he then took up a handful of tea and rubbed that also over the arms, until it had acquired a coating of the colouring matter; it was then flung into a heated copper and thoroughly dried. Green tea therefore is mainly ordinary tea, *plus* Prussian blue or indigo and Chinaman's sweat! The microscope, or even an ordinary pocket lens, enables one to pick out the particles of colouring matter easily, and analysis shows that green teas yield frequently about double the amount of iron obtained from black. Some time ago a good deal

of fuss was made about the adulteration of tea with iron filings, a plan that seemed at first sight very unlikely. The truth seems to have been that occasionally magnetic iron oxide was found, coming, in all probability, from the soil in which the tea was grown. I have found a few minute particles of this substance on two occasions only, out of a considerable number of analyses. Another sophistication, however, that is found in the best teas, and has not been much noticed hitherto, is the addition of the stalks and twigs. When the tea is picked the leaves are collected and freed from stalk, but all the portions of stalk or fine twig are put together and carefully added in certain proportions before the article is ready for the market. Doubtless the whole plant yields theine to a certain extent, but the greatest amount is in the leaves. Fortunately we have a great resource that will serve to keep the Chinese supply from hopelessly deteriorating, namely, the tea plantations of India, which yield an article that even now commands a higher price, and will no doubt continue to improve as years go on. In one way the state might easily improve our existing supply, viz.: by insisting on inspection and sampling of every shipload that comes to the country.[1] All *lie-tea* and such like rubbish ought to be burned, and none admitted that does not come up to a reasonable standard. Considering that the poor, who buy their articles in small quantities, pay generally more than the rich, it is but fair that they should be supplied with a decent article.

[1] Provided for in the new Act.

Coffee is an article of comparatively small consumption in this country, partly because tea has always been so easily obtainable, and partly because it is so badly prepared. The greatest blow, however, that it has received has been the introduction of chicory, a substance with an empyreumatic taste, and utterly devoid of any of the neurine influences of the real coffee. As it only too frequently happened that chicory more than predominated, the consumer would find that the exhilarating effects looked for from such a beverage were almost entirely wanting, and that they might be found in a certainly greater degree even in the poorest tea. Chicory is one of the things that we owe to the great war of the beginning of this century, when the blockade of the Continent compelled the French to exercise their ingenuity to provide substitutes for colonial produce. So also sugar was obtained from beetroot, sulphur for gunpowder from gypsum, and numerous ingenious applications of chemical and practical knowledge were made. Were it merely chicory that was introduced into coffee, it would be less matter, but even that substance itself is adulterated with roasted horse-beans, and other even less desirable ingredients.

Cocoa, now becoming an important article of consumption, is almost always adulterated by the addition of starch, and also very often by colouring matter of an earthy kind; both of these additions are easily detected by chemistry, and the microscope. Sugar, too, is a not unfrequent addition.

Perhaps no class of substances has been more the

subject of adulteration than alcoholic liquors, whether it be beer, wine, spirits, or liqueurs that are examined. As regards beer, the most important question in this country, we may safely acquit the great brewers of the sin of adulteration, the greater part of it being carried on by the inferior class of brewers and the retail dealers. The chief adulterations are the following :—Dilution with water, and the addition of colouring matter and coarse spirit; the addition of salt, tobacco, pepper, capsicum, cocculus indicus, &c. Of these, cocculus indicus is strenuously denied by the trade, but it is a fact that for years large quantities have been imported, that it has been found in beer, and that there is no other known use for it in the arts. Bitters, other than hops, are also added, and even strychnia has been suspected, although erroneously, I fancy; any of these can be detected by the persistent character of the bitter, and its presence in the evaporated extract. That beer, as ordinarily sold in public-houses, is for the most part adulterated, is pretty certain; and an amusing instance of this was given to me by Professor Maclean. He was called to see a publican, who was a great gin-drinker and was suffering from certain affections consequent on his habits. As it was desirable that he should drop spirits, it was suggested to him to take a glass of beer instead; he mused for a little, as if thinking where he could possibly get a drop of the genuine article, and ingenuously remarked, 'I must not drink my own beer!'

In the case of wine, the adulterations are numerous, and may be classified as follows :—

1. Mixture with other and inferior kinds of wine.
2. The addition of alcohol.
3. The addition of colouring matter.
4. The addition of sugar.
5. Plastering, so called.
6. The addition of matters entirely foreign to the grape.

The first form of adulteration is certainly the least noxious, if only genuine wine is employed. The second, the addition of alcohol, is almost universal; hardly any wine, except perhaps from newly-opened-up wine countries, being imported into this country unbrandied. It is almost impossible to meet with a sherry or port of less than 18 per cent. of alcohol (vol. in vol.), at least two per cent. above the extreme maximum of natural wine. When alcohol has been added in large quantity, sugar is also added, to render it less fiery, and to raise the specific gravity; this is probably the case with all ports. When excess of acidity occurs, plastering is resorted to; the murk is mixed with plaster of Paris, lime is precipitated, and sulphate of potash formed. This is a pernicious arrangement, as it introduces a quantity of a bitter and unwholesome salt, and removes part of the valuable constituents of the wine. It requires some care and judgment to do it well, for wine, if too much deprived of acid, becomes flat and unpalatable, and if wholly de-acidulated absolutely nauseous. As in the case of tea, so also in the case of wine, the palate of the taster is the best judge as yet of the quality and value of the article; and we may lay it down as a fair

general rule that if a wine is agreeable to the palate, not too acid, too fiery, or too sweet, and of a specific gravity not far removed from that of water, it will, in most cases, be a fairly sound and genuine article; or, at least, as much so as one is likely to get in the market in the present day.

The adulteration of spirits consists for the most part in the harmless addition of water. In a large number of samples sent some years ago from Malta, where they were supposed to be largely adulterated, I could find in no case any addition but water. That other substances are added is probable, but the chief danger is the presence of fusel oil in new spirit, the effects of which upon soldiers I have sometimes seen most severe. Colouring matter is of course often added, all spirits as first distilled being white, and afterwards coloured (according to fashion) with caramel.

The adulteration of drugs, which would have been an interesting point for the society, there is not time to consider.

Let us now consider food from a dietetic point of view. On this point I must be very brief, and merely indicate a few of the leading facts, as far as we know. The knowledge of the kinds of food necessary for the animal economy was merely empirical up to times within the memory of some now living. Although in a general way it was known that a mixed diet was preferable, yet the true scientific reasons were impossible to be understood, from the inadequate knowledge of chemistry that then existed. From the researches of Liebig, Mulder, Gay-Lussac, Raspail, Boussingault,

Majendie, Prout, and a host of others, we are now able to say positively what are the chief nutritive principles that must be afforded in order to preserve life and health. These are, in the most general classification, as follows :—

Organic matter.	Nitrogenous matter.
Mineral matter.	Carboniferous matter.

By supplying food, even on these general principles, life, and even fair health, may be maintained; but the maximum of work or efficiency will not necessarily be got out of the individual. We require to proceed further into our division, and separate the kinds of food in each section. Thus, the nitrogenous food may be divided into the assimilable and the non-assimilable. Of the former we have albumen, fibrin, and casein in the animal kingdom, and gluten and legumin in the vegetable. These are what were originally called protein compounds by Mulder, who was the first to show clearly grounds for considering the vegetable and animal constituents to be identical, the gluten corresponding to fibrin, and the legumin to casein. It would seem to be indifferent which of these constituents is taken as the chief nitrogenous element, but apparently a mixture is best calculated for perfect nutrition. Of the non-assimilable nitrogenous substances may be mentioned chiefly gelatine and the juice of meat. I call these non-assimilable, not because they are so entirely, but because they are incapable of supporting life alone, that is, as the only nitrogenous substance. It would seem, however, that the mixture of the two,

Protein

or, in other words, the addition of osmazome to gelatine, is more easily assimilated than either singly. Osmazome or flesh-juice, is represented by beef-tea and the various essences of meat in the market, all of which must be looked upon as stimulants rather than nutrients.

The carboniferous matter must be divided into fats and carbo-hydrates, the latter including starch and sugar. These substances may be allowed to take each other's places to a certain extent, but they cannot do so entirely, except under peculiar circumstances of climate, race, temperament, &c. Thus, the Arctic people rarely touch any carbo-hydrates, their place being entirely taken by fats. On the other hand, both carbo-hydrates and fat enter largely into the food of the tropical Indian or African. We shall probably, hereafter, have to draw a marked distinction between the action of starches and sugars, although at present we are much in the dark concerning them. At all events, our own sensations tell us the difference, and few people would be contented with a teaspoonful of starch in place of sugar in their tea or coffee.

As regards mineral matters, the chief requisites are chlorides and phosphates, the former to keep up the supply of hydrochloric acid necessary for digestion, and the latter to preserve the requisite rigidity of our skeleton, and probably also to supply our nervous system. With the exception of sodium chloride, our mineral constituents are almost entirely taken indirectly with other articles of food and drink.

The general principles of diet may be summed up as follows :—

1. No single nutritive principle, whether nitrogenous or carboniferous, can support life except for a very short time.

2. Life may be supported upon one nitrogenous and one carboniferous principle for a long time, but for a permanency salts would require to be added. Thus albumen and fat, albumen and starch, or albumen and sugar would support life; or any of the other nitrogenous principles, such as fibrin, casein, gluten, or legumin, may be substituted for albumen.

3. Gelatine cannot take the place of any other nitrogenous principle alone, although it may do so partially when mixed with osmazome.

4. For the best form of diet both fats and carbohydrates are required, in addition to nitrogenous matter, and in all probability both starch and sugar among the latter. It would also appear that a due admixture of more than one form of nitrogenous principle is advisable.

5. The only single article of food that can support life properly is milk, the next best is bread.

With regard to the vexed question of stimulants and neurines, it is difficult to deal much with it in so brief a space. I will therefore state briefly the conclusions I have arrived at myself.

Alcohol can be dispensed with by many people, and might be so by more, with advantage. At the same time, in moderation I think it useful. It ought, however, to be taken considerably diluted and not in greater quantity habitually than can be destroyed by oxygenation in the system. This is on an average from

one to two ounces of absolute alcohol in the twenty-four hours, representing one to two pints of beer, or half a pint to a pint of claret, or two to four glasses of sherry, or one to two glasses of brandy. It ought to be taken with meals, generally with the fullest meal, or quite at the end of the day. Occasions may of course arise for abstinence for one or more days, just as is the case with food. I am sure, if some such rules as these were adhered to, we should hear very little of the evil effects of alcohol. But in view of the enormous amount of misery and crime that is the result of drinking I am not surprised that well-meaning people should advocate permissive bills and the like, although I disagree with them *toto cœlo* in their proposed means of repression.

The question of tobacco is one of less importance, but its use is so general that it is necessary to say a few words about it. Perhaps there are few things in so frequent use about which so little is really known. It is probably not a necessity; it is certainly injurious in some cases; but it appears to give so much enjoyment without any very evident harm to a large number of people that one would hesitate to condemn it, except on grounds very much better than at present exist.

With regard to the use of opium and other narcotics, which is said to be increasing in this country, I think they may be safely condemned as improper, except under medical advice, and I think the legislature might very properly prohibit their sale, except on the prescription of a registered practitioner.

The action of the other neurines, such as tea, coffee,

and cocoa, is admittedly good in the large majority of cases, but it may be pushed too far, and I am convinced that much dyspepsia is caused by the imprudent use of tea. In particular, the modern practice of five o'clock tea is a most pernicious one, and I am happy to see that Dr. Pavy has added the weight of his opinion against the practice. When people eat breakfast and lunch they can surely wait for dinner, without diluting their gastric juice and injuring their nerves in so foolish a way.

We have now to consider food in its productive aspect, in respect of the work which can be got out of its consumer. Up to ten or a dozen years ago, the views on this subject were very erroneous, the generally-received notion being that it was the chemical changes in the structure of the tissues themselves, particularly the muscles, that provided the force necessary, whilst the nitrogenous matter supplied the waste. At the same time, the carboniferous matter was supposed partly to dilute the nitrogenous, and partly, if not chiefly, to supply animal heat. As usual there was some truth here, along with a good deal of error, and the theory was far from satisfactory to many enquirers. When at last the modern views of the conservation of energy became more clearly developed it was then seen that there was more resemblance between a steam-engine and the human frame than was previously supposed, and that to credit the chemical changes of nitrogenous tissues with the production of active force was not more philosophical than to refer the force of a steam-engine to the wearing away of its wheels or pistons. Experimental enquiry, especially by Fick and Wislicenus,

Pettenkofer and Voit, Parkes and others, showed that, while there were notable changes in the amounts of carbonic acid and water eliminated, the amount of urea remained pretty nearly constant, varying only with the amount of nitrogen ingested. In some cases it actually diminished under exertion, apparently going to increase the bulk of the muscles thrown into active movement. From this it was concluded that the nitrogenous matter could not be credited, except very partially, with the production of active force, and that it was produced really, in greatest part, from the potential energy stored up in the carboniferous food and set free by oxygenation in the system. The determination of this energy was next set about and worked out by numerous observers, especially by Frankland, although previous to him both Joule and Playfair had made valuable experiments in that direction. I may briefly mention the method of estimating. The material to be examined is dried, reduced to powder, and thoroughly mixed with a highly oxydising substance, such as potassium chlorate; it is then enclosed in a calorimeter and combustion started, the heat imparted to a surrounding mass of water being taken as the measure, and the raising of one gramme one degree of centigrade, called a *heat unit.* It is then easy to calculate what work this heat would do when converted into mechanical force, and accordingly we find that 1,000 heat units would give enough of force to raise 424 kilogrammes through one mètre. Converting this into our own measures we find that 1,000 heat units, or 424 kilogramme mètres, are equal to 3,060 foot-

pounds, or that number of pounds raised through one foot. Or we may state it that 1 pound of water raised through 1° F. equals 772 foot-pounds. When we have to deal with rather large quantities it is convenient to talk of *foot-tons*, or the force required to raise a ton through one foot; to reduce foot-pounds to foot-tons we have simply to divide by 2,240. Thus 1,000 heat units are equal to 1·36 foot-tons; 1,000,000 gramme-mètres (or 1,000 kilogramme-mètres) are equal to 3·22 foot-tons, and so on. In a number of cases it is possible to calculate out the actual amount of productive work done in this manner. Thus what is known as one-horse power is equal to 33,000 foot-pounds, or about 15 foot-tons. Raising a weight a direct altitude can always be calculated out in this way; thus, a man weighing 150 pounds who raises himself by means of a rope through a height of 100 feet does work equal to 15,000 foot-pounds, or about 6¾ foot-tons. If he raises himself through a mile in height then the work is equal to 792,000 foot-pounds, or about 352 foot-tons. The calculation, however, is not always so easy; for instance, in the case of a man walking. It has, however, been worked out for us by Professor Haughton, of Dublin, from data calculated by the Messrs. Weber, of Göttingen, and he finds that at about three miles an hour the work done in walking is equal to one-twentieth of work done in direct ascent. Thus a man walking twenty miles on the flat, at three miles an hour, does as much work as if he raised his body through a mile in direct altitude. It is generally found that a fair day's work for a man of average weight

and height is about 300 foot-tons per day, and this would be equivalent to walking about sixteen miles in a little over five hours. A hard day's work is about 450 tons, equal to walking about twenty-four miles in eight hours; and an extremely hard day's work is 500 to 600 tons, equal to walking twenty-six to thirty-two miles in nine or eleven hours respectively. I may mention a few instances of work[1]:—

	Foot-tons.
Work in a copper rolling mill, extreme . .	723
,, ,, usual . .	443
Pile driving	312 to 352
Pedlars always loaded	303
Paviours	352
Military prisoners, shot drill, oakum picking and drill	310

From my own observations:

Leptcha luggage coolies	500
Palanquin bearers	600
Native Indians weighing 100 lbs. walking 42 miles	496
Native Indians weighing 100 lbs. walking 50 miles	590
Native Indians weighing 120 lbs. walking 42 miles	595
Native Indians weighing 120 lbs. walking 50 miles	708
European weighing 160 lbs. walking 52 miles	979
European weighing 160 lbs. walking 73 miles[2]	1,378

We must, however, allow a great correction for the velocity with which work is done, and the ratio may be generally stated as inversely as the square of

[1] Haughton.

[2] This was accomplished in about 17 hours, and was therefore equal to about 2,400 foot-tons.

the velocity. From the diagram[1] you will see how this operates. The work in the Oxford boat-race is about 27·25 foot-tons per man, but then it is done in *seven* minutes,[2] so that it is really equal to from 465 to 500 foot-tons spread over a day. In order to produce the above-mentioned amount of productive work a much larger amount of potential energy has to be expended. In the first place, the work done by the heart is estimated, from Haughton's experiments, to be about 260 foot-tons; then the animal heat absorbs a large quantity, which we estimate at about 2,000 to 2,500 foot-tons. Then it is calculated by Helmholz that, out of the potential energy over and above what is supplied for the internal work of the body, about *one-fifth* can be obtained as productive work. This is true only of ordinary work, equal to not more than about 50 foot-tons per hour, but for more severe work much more fuel is necessary. It is known that the energy expended in mechanical force varies nearly as the cube of the velocity, and this appears to apply to the human frame as well. It would also seem that a merely increased amount, within a given time, without an actual increase of velocity, causes a greater expenditure of energy. I have calculated the potential energy both from the food ingested and the CO_2 eliminated, and find it tolerably coincident, giving about 2,800 foot-tons as the amount required for the internal work of the body. For an ordinary day's work of 300 tons we have to add (as is proved by experiment) five times as much, or 1,500 tons; for a

[1] See Table XVI. [2] Maclaren.

hard day's work of 450 tons, about 2,050 tons, or *five* times the first 300 and *seven* times the next 150. The data are as yet imperfect, and experimental enquiry is surrounded with many difficulties, but I think we have here glimpses of a law which may be stated as follows:

The maximum of potential energy we can expect to be converted by an average man will be equal to

$$300 \text{ foot-tons} \times \left(5 + \tfrac{7}{2} + \tfrac{9}{4} + \tfrac{11}{8} \quad . \quad . \quad . \quad . \quad \right);$$

now, this series summed is equal to 14, and $300 \times 14 = 4{,}200$ as the total amount of potential energy which can be converted in the body. The actual productive work will be equal to

$$300 \times \left(1 + \tfrac{1}{2} + \tfrac{1}{4} + \tfrac{1}{8} \quad . \quad . \quad \right) = 300 \times 2 = 600 \text{ foot-tons},$$

or *one-seventh* of the potential energy. If now we add on the amount required for the internal work of the body, viz. 2,800 foot-tons, we have a total of about 7,000 foot-tons as the maximum of potential energy the human frame is able to deal with.[1]

From the diagram[2] you will see the amount of potential energy required under various conditions, calculated from the CO_2 eliminated, partly from Pettenkofer and Voit, and partly from Edward Smith. Thus, the former give the amount for twenty-four hours as 911·5 grammes in a state of rest; now, each gramme of CO_2 is the result of 3·01 foot-tons of energy, so that the amount is $911{\cdot}5 \times 3{\cdot}01 = 2{,}744$. The amount for a man of 160 lbs., for which the table is calculated, I have taken as 2,815, probably the amount necessary to keep a man alive without losing weight, in a state of com-

[1] See Table XVII. [2] See Table XVIII.

plete repose in the recumbent position.[1] Even the action of sitting up increases the amount, and standing still more so; 141 in the former, and 163 in the latter case. The amounts expended at different degrees of velocity are also given, and the progression is tolerably complete, except between two miles an hour and three miles an hour, where there seems to be some slight discrepancy. Five miles an hour is not given by Edward Smith, and is merely interpolated. One curious result comes out, viz. :—That there is a velocity at which the maximum amount of work can be done at the minimum of expenditure. By dividing the expenditure by the velocity, we find that at three miles an hour one mile can be done for 179 total foot-tons, which is less than at any other velocity. We might, therefore, accept this provisionally as the most useful rate of work; it is the velocity of the ordinary quick march of troops, and it is about the rate that most people drop into for easy walking when not overburdened. This, for a day of 300 foot-tons of labour, would be equivalent to a man raising his body through four-fifths of a mile in direct altitude in about five hours of actual labour. Eight working hours at this rate would produce 430 foot-tons, or would be equal to raising the body through $1\frac{1}{10}$ of a mile in the time. Of course ordinary work is nothing like so continuous as this, but the above rate, with short intervals of rest, is probably a favourable amount. We may say that, if a man does as much as is equivalent to raising himself through from four-fifths to one

[1] = 117 per hour.

mile, he does a very good day's work. On the other hand, for health, no man ought to do less than a certain amount of bodily work, or he ought to regulate his food accordingly. For average men of more or less sedentary occupation, not less than 100 to 150 foot-tons of exercise per day ought to be taken, equal to walking for from two to three hours at a moderate pace, or equal to raising the body through about 450 to 650 yards. What the expenditure in mental or sedentary work is has not been calculated, but it is certainly too much in one direction to be sufficient for the general health. It will be easily understood that these rules apply only to adults in full health and vigour, and that they must be much modified to suit the cases of growing children, and persons whose sex or health incapacitate them from the full exercise of average power. In the case of children, it is obvious that the greater part of the potential energy must be stored in building up the growing tissues, and that, therefore, much less ought to be demanded of them proportionately. Accordingly, a child weighing 80 lbs. ought not to be called upon to do the half of the work done by an adult weighing 160 lbs., but something less, probably in the ratio of the squares of the respective weights. A similar limitation ought also to be placed to the work of women, for, although in some countries they are put to as hard or even harder work than men, it is obvious that they are really incapacitated from preserving full health and vigour under such circumstances, both from original feebleness of frame and also from the more delicate poise of their physiological

condition. It may sound socially ungallant, but it is, nevertheless, physiologically true, that a female must be looked upon in certain ways as an *arrested male*, and that generally speaking she must be regarded as the equivalent in strength to a lad of about sixteen or seventeen years of age, and her work ought to be apportioned accordingly. I have left myself but little time to discuss the part the State ought to play here, but I think I have indicated the direction its interference ought to take. When we consider what used to be the condition of factories formerly, our astonishment is that children, particularly, survived at all. It was proved that work was carried on so continuously that when a child was called out of bed another went into it, he vacating it again for the former when his turn came round. There was no rest from work, and the bed was never empty or aired. It is obvious that for the protection of unfortunate victims who cannot help themselves, the interference of the State is necessary, and it is satisfactory to learn that in the present day employers of labour are becoming more alive to the fact that it is not only just that the worker should be well cared for, but that it is also remunerative, more and better work being got out of him when he is properly housed, sufficiently fed, has a well-ventilated workshop, and his powers are not overtaxed. Every tyro in mechanics knows that only a certain amount of work can be got out of a certain amount of fuel, that the fuel will not burn without a free supply of air, and that the works of an engine must not be kept at full strain if they are expected to last. But it is

only in these later days that men have come to understand that their bodies are merely machines of a more delicate and complicated kind; that they need fuel in the shape of appropriate food, and an ample supply of fresh air for its combustion; and that their nerves and muscles must not be strained to the full, under pain of breaking down altogether. In some sort, this ignorance has been due to the vanity from which has grown the notion that we are beings apart from all others, and as such under other laws. But our pride has at length begun to 'take physic,' and we are beginning to acknowledge that we are in this earth of ours merely the highest integrations of the ordinary force, which in its various forms governs the Kosmos, from the dropping of an apple to the crash of worlds.

LECTURE VI.

PREVENTION OF DISEASE—CONTAGIOUS DISEASES ACTS—LAWS OF PROPAGATION OF DISEASE—EPIDEMICS—STATISTICS, THEIR METHODS, OBJECTS, AND IMPORTANCE—CONCLUSION.

In concluding this course I wish to say a few words on the prevention of disease generally, involving therein some remarks on its modes of propagation and the views entertained on the question by different observers. This might be considered as the sum of the whole matter, for all the aim of State Medicine is the prevention of disease, and the various points touched upon in the previous lectures were all directed to this end. It is not, however, with the view merely of going over ground already trodden, but to consider briefly the practical application of some of the principles laid down and the future prospects of sanitation generally.

It is obvious that the efficacy of the methods for prevention of disease depends a good deal upon our knowledge of its origin and its mode of propagation, and, failing such knowledge, upon the view or theory we hold. Thus a disbeliever in contagion will probably think isolation of infected cases unnecessary, and look upon quarantine as a delusion. A disbeliever in malaria might be expected to be indifferent as to

whether a house was built in a marsh or not; he who refuses to accept the possibility of water conveying disease may, we might fear, look with indifference on the pollution of wells and watercourses; he who denies the existence of syphilis will of course oppose the Contagious Diseases Acts, whilst the believer in magnetic or cosmic influence may well fold his hands and say, 'Kismut,' ''tis fated.' Although those dangers are not wholly chimerical, yet the effects of theories are greatly modified in actual practice, and accordingly we find that on the whole all are pretty well agreed that, whatever may be the particular view held about the actual *modus operandi* of disease, general unhygienic conditions are at least favourable to it, and a strict adherence to the principles of health as usually laid down will at least greatly modify, if it does not prevent, attacks of disease. Pure air and plenty of it, sufficient cubic space to dwell in, pure water to drink and a plentiful supply for ablution, a sufficient supply of nourishing food, a thorough cleansing in and around habitations and efficient removal of all excreta and refuse, are fundamental points that are acquiesced in by all, and it must be admitted that if these could be secured more than half the battle would be won. But there is still something beyond, for although the strict interpretations of *pure air* and *pure water* would at once exclude the idea of any morbific poison being present, yet we must perforce view the possible introduction of such poison at special times even where purity is believed to be attained. What special means can we use then besides to protect us from disease?

Let it be granted that there is such a thing as a *materies morbi*, that can be communicated in one way or another, and the question is then reducible to disinfection and isolation, including under the latter quarantine.

Disinfection has been much discussed, and various methods proposed, some of which are efficacious, others less so. The objects are the following: 1. To destroy if possible the morbific poison utterly; 2. To suspend its action and arrest its propagation, if destruction cannot be conveniently accomplished. The first is to be accomplished by exposure to free currents of air, by using certain chemical agents, or by heat, either boiling or dry heat. The second may be accomplished by great cold, or by certain chemical substances. The exposure to free currents of air is somewhat uncertain, and probably slow in its operation. The chemical agents which effect destruction of the poison are chlorine, nitrous acid, sulphurous acid, which can be used for fumigation, or chromic acid, the permanganates, and, in a less degree, the salts of iron; but these last substances must come actually in contact with the matter to be destroyed, and cannot be used for fumigating or evaporating purposes. The best of all methods is exposure to heat, both because it is more certain and because there appears to be less danger of destroying fabrics than in the use of the stronger disinfectants. In most ordinary cases boiling is very efficacious, but it is best, when it can be done, to have a greater heat, either by means of steam under pressure, or by gas. A heat of 250° F. is certainly sufficient to

destroy morbific poison, but it is also apt to char clothing; on the other hand 230° F. does not char or singe, and appears to answer for all practical purposes. In one of Ransome's gas disinfecting chambers at the Southampton Infirmary, Dr. Lake enclosed fleas, bugs, lice, and other small creatures, in the middle of a considerable bundle of bedding and mattresses, which were exposed to 230° F. At the end of a few hours they were found not only to be dead, but to be dried up so that they crumbled to powder on being touched. It is hard to conceive that any poison could, under similar circumstances, continue to be active. It ought to be a duty on the part of the local sanitary authority to provide a disinfecting chamber in every village or district of a town, to which the bedding and clothing from cases of infectious disease could be at once removed. At present powers are taken for the destruction of clothing and bedding and granting compensation, but provision for disinfecting also, in cases where destruction may not be possible, ought to be made. And access to such means ought to be easy and immediate, so that there might be no excuse for allowing bedding or clothing to accumulate or lie about. Suspension of the activity of morbid poisons may be effected either by extreme cold (which is, however, not practically applicable) or by the use of such substances as carbolic acid and other vegetable products. Although these agents do not destroy the poison, there is no doubt that they arrest its activity more or less efficaciously, and they may sometimes be applied where it is not convenient to use other means.

The minute organisms, such as monads, bacteria, &c., cease to move or to reproduce in presence of those substances. In water containing tarry matter there is a singular absence of life, as exemplified lately in a sample examined at Netley, which had become impregnated from a pipe with a bituminous lining; the water had a strong smell of tar and was therefore disagreeable to the taste, but, although there was a good deal of suspended matter, there was a remarkable absence of moving bodies. The most important and interesting application of this point is the well-known antiseptic method of Professor Lister, which has had such marked success in Edinburgh, and is now almost universally used in Germany. It is a wise arrangement, even in cases of disease not usually looked upon as contagious, to have the room and indeed the house emptied for a time if possible and thorough cleansing and fumigation applied. Under all circumstances care should be taken to provide as few resting-places as possible for morbid poison, by dispensing as much as possible with curtains, draperies, or other tags of cloth. Yet so little is this understood or attended to that we not unfrequently see both bed and window curtains in hospitals, as if for the purpose of receiving and storing infectious deposits. Other points that require careful attention are the immediate and regular disinfection of stools, and the most scrupulous care against deposits of dust in the sick-room—as this forms a most convenient resting-place for disease poison, particularly in eruptive cases, such as smallpox, scarlet fever, measles, and the like. The particles thrown off from the skin in these

cases are in a dry state and capable, for all we know, of remaining potentially energetic for an indefinite period, like mummy wheat, only waiting to be stirred up and set flying abroad at the next sweeping, to find a new and appropriate nidus.

Isolation.—The second precaution for the prevention of disease is isolation, an all-important one if contagion be recognised as the means of propagation. It is plain that in the houses of the poor, and even in some of those much above that class, isolation is next to impossible; it ought therefore to be the care of the sanitary authority to provide adequate accommodation for the purpose. The importation of a single case of disease is often enough to light up an epidemic if it finds a favourable field; of typhoid fever I have already cited cases, and of typhus there is the well-marked case of Chesham, in Buckinghamshire, in 1871, where the accidental introduction of a single case of typhus was followed by an outbreak which resulted in eighty cases and twenty-one deaths, and would probably have been worse had not hospital accommodation been provided in the meantime and the remaining cases isolated. Of the importance of isolation in the case of smallpox, of scarlatina, and of measles, it is hardly necessary to say much, its efficacy being undoubted, especially in the two former diseases; measles appears to be less easily controlled, perhaps because its particular poison may be more easily carried through the air from its probably small specific gravity. In every instance, however, the isolation ought to be complete, otherwise it will likely fail of effect—that is, the

patient should have no communication with any except his immediate attendants, and the attendants only indirect communication with any one else. All clothing, bedding, &c. ought to be disinfected at once, before being touched by any one having communication with the outside.

Quarantine.—The question of quarantine is a difficult one, but I have little doubt myself that if it could be rigidly carried out it would effectually stop epidemics from without. Its failure hitherto has been due to the merely partial way in which it has been applied, and also to the inherent impossibility of completely effecting it. Carried out as it used to be in many places, it was productive of worse evils than it prevented, and became a positive nuisance. It is a considerable obstruction to commerce, and it may be a question if the good it does is not counterbalanced by the evil. At the same time it would seem reasonable not to admit persons actually suffering from a communicable disease, or their immediate attendants, until a reasonable time had elapsed. The whole question is surrounded with difficulty; disease has actually been traced to importation, and we feel that if we could prevent importation we might be spared an epidemic, so we are loth to give up the means of apparent prevention. On the other hand, complete prevention is practically so all but impossible, that it would probably be best to look the thing fairly in the face and acknowledge its inutility, trusting to careful hygienic measures and isolation, as far as possible, of the actually sick.

Contagious Diseases Acts.—There is one special branch of isolation of great interest and importance, namely, the prevention of venereal disease, under the Contagious Diseases Acts. Perhaps no subject in recent times has called forth so much controversy, and the question has been discussed in its various aspects, scientifically, ignorantly, wisely, foolishly, enlightenedly, and fanatically. The Acts, as is well known, were obtained for the purpose of diminishing as far as possible the sources of disease in certain garrison towns and seaports, and so lessening the excessive amount of syphilis that was telling so much upon our soldiers and sailors. Similar Acts had been in operation on the continent of Europe for many years, and syphilis there was much less prevalent than in this country. In Malta, too, under our rule, they had been applied for a considerable time. The history of the Maltese experience is interesting; about sixteen years ago some worthy people, considering that the existing Act was favouring vice, got it suspended for a time; the consequence was that venereal disease increased so much among the troops that all the medical officers joined in a representation to the Government, in consequence of which the Police Act was again put into operation, and the venereal rate again fell as before. Compared with Gibraltar also, where the same means did not exist, the amount of disease was very small. A similar Act has recently been introduced in Calcutta, with most excellent results, as shown by the letter of Surgeon-Major Payne in a recent number of the 'British Medical Journal.' This is all the stronger testimony as the

application of the Acts there was attended with very considerable difficulty, both on account of the ways and habits of the people, and also on account of the less trustworthy character of the agents who had to be intrusted with carrying out the provisions. In this country, in spite of what has been written to the contrary, the operation of the Acts has been decidedly successful, although the most strenuous attempts have been made by all sorts of people to decry them, and not only that but to prove even that they greatly increased the evil they attempted to cure, although how they could possibly do that is, I think, hardly plain to anyone in his ordinary senses. Let me say a few words: 1. On the necessity for the measures; 2. On the objections to them, physical, moral, religious, and sentimental; and 3. On their degree of success.

1. *Necessity for the measure.*—It is only necessary to turn to the army and navy returns to see what an amount of sickness was due to those diseases, but what the returns do not show is the extent to which they influence the health of the troops generally, and the way in which they induce and aggravate diseases that appear ostensibly under other heads. With regard to the actual number of admissions in the army for primary venereal sores and gonorrhœa, we have Dr. Balfour's table, Vol. VIII. of the Army Medical Reports. It is there shown that in 1864, before the operation of the Acts, the admissions per 1,000 were—for primary venereal sores, 108·6; for gonorrhœa, 112·6; that is, about *one-fourth* of all the admissions were for

primary venereal disease. I remember myself that, the the total number of sick in a battalion being fifty, the cases of venereal disease of all kinds were frequently twenty-five, and sometimes rather more, so that it happened at times that one-half of the sickness was due to that cause. Turning to the return for 1860, we find that at Portsmouth the admissions for enthetic disease were 503 per 1,000, and in 1861, 485. The total admissions for the army at home were 354 per 1,000, and the loss of service amounted to 8·56 days per man. The number constantly sick from all causes amounted to 54·54 per 1,000, of which enthetic disease furnished 23·45, or 43 per cent. Reckoning the value of a soldier at about 100*l.* per annum, this loss of service amounts to about 221,000*l.*, without including the indirect loss through other diseases aggravated or influenced by this class. As regards this important aspect of the question, I may mention those diseases which are chiefly influenced:—Diseases of the heart and great vessels, diseases of the cerebro-spinal system, phthisis, rheumatism, ophthalmia, and skin diseases. Cardiac disease, aneurism, phthisis, and paralysis are four diseases which cause a large part of the death and invaliding in the army, and the connection of them with venereal disease is undoubted. The testimony of the dead-house at Netley is grimly significant, hardly a body being opened there that does not show traces of syphilitic influence, very generally in the shape of atheromatous degeneration in the coats of the aorta. Could we stamp out syphilis we should at once reduce our sick-list by at least *one-fourth*, and

ultimately by at least *one-half*, whilst the death-rate and invaliding-rate might be lowered by a very large amount. At Malta, in 1861, the fourth battalion of the Rifle Brigade, to which I then belonged, had only 496 admissions for all diseases per 1,000 of strength, about the same as the troops at Portsmouth and Plymouth had for enthetic disease only, and less than Portsmouth had in 1860. The average admissions in the home army for enthetic disease was, as I have already said, 354 per 1,000; in Malta, 102. Again, in the Crimea, in 1856, where circumstances completely eliminated sources of venereal disease, sickness almost entirely disappeared—in many battalions being less than *one* per cent., and in some there not being a man that could not have paraded for duty. It seems to me that this is a crucial test that has hardly been sufficiently regarded as to the possibility of stamping out the disease.

2. *Objections.* The objections advanced against the Acts are chiefly these :—

1. That they have been unsuccessful, so much so that disease has actually increased in consequence of them.

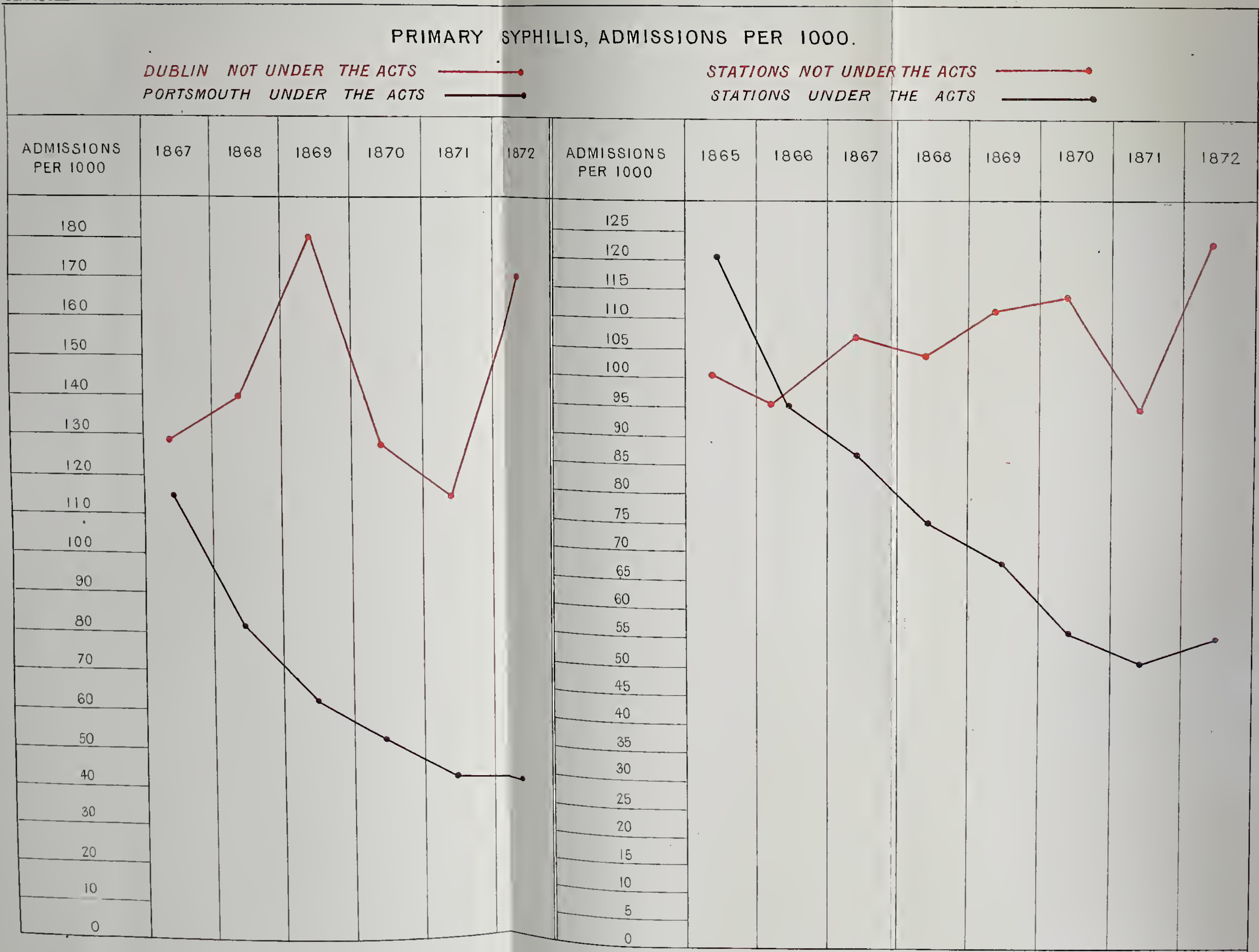
2. That they are immoral, in that they give official recognition to prostitution, and put a premium upon vice by providing safe means of gratifying the passions.

3. That they are demoralising to the women examined, who are unnecessarily degraded by them.

4. That they are contrary to divine law, which has appointed the disease as a punishment for sin.

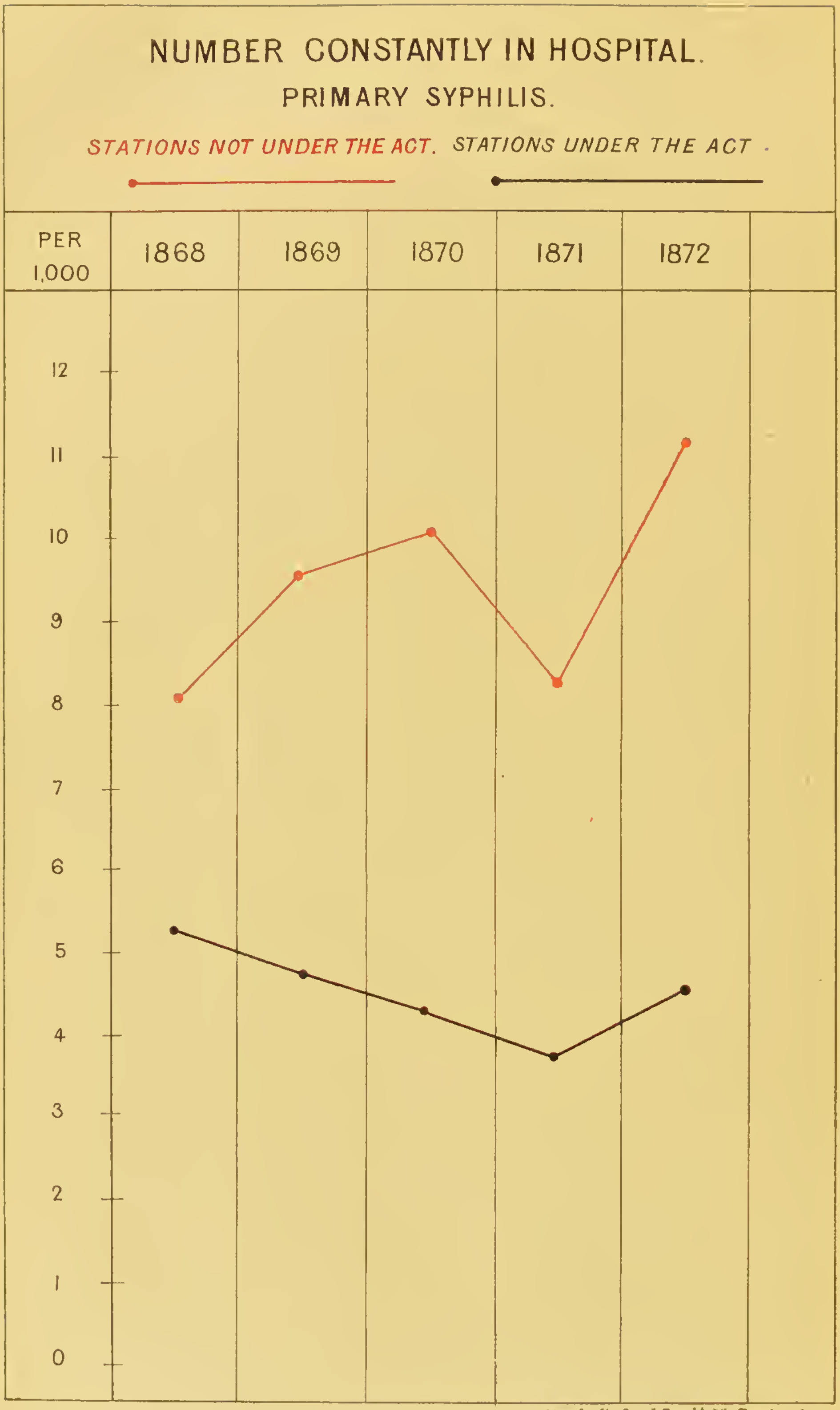
Taking these objections *seriatim*, we find it stated that the Acts have been unsuccessful, and that they have

Table XIX.



Stanford's Geog¹ Estab¹ 55 Charing Cross.

Table XX.



Stanford's Geog^l. Estab^t. 55 Charing Cross.

actually increased disease. A glance at the diagrams[1] will show some instances which may be taken as examples of their operation. Looking also to Dr. Balfour's tables, we find that in the years 1865–71, the average admissions in the stations under the Acts were 65·3 per 1,000 for primary venereal sores, against 101·3 in the stations not under the Acts; whilst for the year 1871 itself the admissions were 52. Again, turning to the returns from Malta, we find that in 1859 the admissions for enthetic disease were 149·3 per 1,000, of which 77 were syphilitic, and in 1860 147·9, of which 106 were syphilitic. This was the period when the police surveillance of the prostitutes was suspended. In the middle of 1861 the police regulations were again enforced, and the total enthetic ratio was reduced to 102 per 1,000. In 1862 it was still further reduced to 49·5, the reduction being almost entirely in the syphilitic cases; and in 1871 the amount was only 8·3 for primary syphilis, and 5·2 for secondary. It is true that in 1872 there was again a marked increase, but this was traced to the influence of certain abandoned women, nominally the wives of the soldiers, who, as such, escaped the influence of the Contagious Diseases Acts. A good deal has been made of the recrudescence of the disease from time to time, as showing the failure of the Acts, but until the disease is utterly stamped out, this is only what might be expected. On the other hand, the violent fluctuations seen in the stations not under the Acts are much greater, so that the legitimate inference is that, if things

[1] See Tables XIX. and XX.

are bad in spite of precautionary measures, they would be so much the worse without them.

2. With regard to the assumed immorality of the Acts, we have only to say this, that prostitution exists, that it has existed from all time, and that there is no reasonable hope of its ceasing within any time that we have proximately to deal with. Prostitution is, however, no more recognised by the Acts than before. As to the providing safe means of vice, no such idea was contemplated; it was simply acknowledged that we had to deal with the strongest passion in our nature, a passion that men will brave anything to gratify, and the object was to prevent men suffering so far from the evil effects of it as to make them less burdens to the community, either through personal infirmity or by transmitting disease to an innocent offspring.

3. That the Acts degrade the women themselves is best answered by the fact that prostitution has on the whole diminished, and that many have been reclaimed. In particular, juvenile prostitution has all but disappeared in stations under the Acts. I cannot help saying at the same time that the people who raise the objection must be themselves either very innocent or very disingenuous if they pretend to believe that an examination, conducted as it is with every propriety by a professional surgeon, is likely to degrade in any way the unfortunate women who are chiefly frequented by soldiers and sailors. Objections have been made also to women being examined and not men as well. In answer to this it may be said that both soldiers and sailors were examined long before the women were ever

subjected to examination; but what may be done with men under authority would be impossible with civilians, besides which the one sex makes a trade of it, or rather is driven to do so, and, therefore, must be dealt with. The death of a poor woman some little time ago at Aldershot has been much harped upon as an instance of the cruel tyranny of the Acts and of the police who administer them. Even supposing the facts as stated were true (which there is not sufficient evidence to show) I submit that they prove nothing more than a *primâ facie* case for enquiry into the conduct of the police. The Great Coram Street murder, it will be remembered, caused the accidental arrest of a German clergyman, under very extraordinary circumstances. That gentleman, although discharged without any stain attaching to him, was, while in confinement, subjected to various indignities, but it was not proposed in consequence that no one should ever again be arrested on suspicion for murder, although the circumstances were good grounds for enquiry into the regulations of prison discipline. Quite recently, too, a poor woman drowned herself in a cistern after receiving a school-board summons; but would it be well to leave the population in ignorance for fear such an accident should occur again? I believe, however, that so far from any tyranny or cruelty being practised, the police have conducted their difficult duties with great tact and discretion.

4. Lastly, with regard to those who look upon venereal disease as a punishment appointed for sin, I would simply ask, in the words of the Great Master,

'Were those on whom the tower of Siloam fell sinners above all others?'

Laws of propagation of disease and epidemics.—In discussing the laws of propagation of disease and epidemics, we have before us a wide field, the margins of which have been much trodden in these later years. How much progress has been really made is a very doubtful point, for matters seem to be left very much where they were. A few things have been certainly made out, and some fallacies got rid of, but we are still as far as ever from any real knowledge of the origin of disease, although we have numbers of theories on the point. We have some advocating the view of a general morbific poison, whose special varieties produce particular maladies; others, who deny any special poison whatever; some insist upon it that each disease has its own special germ; whilst others are equally sure that the germs may arise *de novo*. Some credit a fungus with the bad pre-eminence, and some adopt the bacterium as the *fons et origo mali*. It would be obviously impossible to discuss even partially the various theories, but some points present themselves more prominently than others, and suggest a few remarks. In particular, the vexed questions of the existence or not of special germs of disease, and the possibility or otherwise of their generation *de novo* seem to claim some attention. I think it may be safely said that the majority of observers are in favour of the view that there is a special poison which produces a particular disease, even where they are at variance as to the origin or means of transmission. The evidence is still

in favour of this view, no trustworthy facts being on record that show that any specific disease has ever been produced from any other, or that it has been the parent of any other. It is true that it has been suggested that in process of time hybrids might be produced, as in the case of the curious malady (Röthelen) that appears to lie between scarlet fever and measles. But this would be more a proof than ever of the special nature of the poison. Again, it has been suggested, and with probable truth, that the doctrine of evolution may be applied to diseases as well as to known organisms. This, again, does not invalidate the special existence of germs, but goes rather in the other direction; the only danger being a too hasty application of the doctrine, which is often misunderstood. At no time does the doctrine of evolution ever contemplate the direct change of one organism into another, but the gradual development of one type into another through a long series of slow changes. Another important part of it is that when organisms become determinate in a particular direction, and reach a high state of perfection, then the chances of further evolution become greatly lessened, if not nullified. It is only within a certain limit of progress that an organism is plastic enough to admit of possibilities of variation in the direction it may take. It would seem, on the other hand, that under existing conditions the integration of matter has a limit, which may be different in different directions, and that when this limit is reached, the type tends to decay; at the same time this limit may be shifted in the course of ages, and fresh integrations starting from other points

may reach a higher stage. In this way man has hitherto been the most advanced type of integration, but we are unable to say whether he has reached the limit or not; but if he has, the race must die out, and its place be taken by some other form. It may be the same with the germs of disease, and probably from their undoubtedly low type of life the limit of integration may be sooner reached. Thus, I think it not improbable that some diseases may disappear altogether, before we are able to discover their nature, from sheer natural decay, just as types of plants and animals have done. It may also happen that we may stamp them out at an earlier period, just as we have done to races, animals, and plants. Our only hope, then, of knowing what had formerly caused cholera, typhus, scarlet fever, and the like, will be an archæological enquiry, such as that which has deciphered the Egyptian hieroglyphics, or opened out for us the history of the Accadians. But such knowledge will doubtless have its value as a key to the nature of future developments, and may furnish us with the means of arresting and effectually preventing the process of morbific integration when new diseases threaten to become imminent. On the other hand, what value are we to attach to the theories of spontaneous origin of disease, of which Bastian is one of the most noted expounders? The theories may be limited to two: 1. New germs may arise out of previously existing organic matter, which may be organised or may not; at all events, the resulting substance is a something which has a life totally different and distinct from its immediate parents. 2. Germs may arise

directly from certain combinations of inorganic matter. With regard to the first view, it is not borne out by a single particle of evidence of any real value. We may go as far down as our appliances will allow us in the organic kingdom, but there is no evidence that the most minute organism or dot of protoplasm will ever produce an organism other than that it sprang from itself. Even in the low debatable ground between animal and vegetable, it is still possible to differentiate between the two as far as we have yet gone. The main grounds for the belief in heterogenesis is, not that it has been in any way traced, but that, by a process of apparently negative results, the conclusion has been arrived at. But no amount of negatives can be of much value without some positive result, and the mere fact of not seeing the originating germs is simply a confession of the imperfect nature of our methods. Considering the extreme minuteness of the forms of bacteria it is not to be wondered at, if they spring from gonidia, that the latter should elude the most careful observer. Again, the fact of organisms making their appearance in solutions after exposure to high temperature, merely shows that the germs have either not been fully exposed to the temperature, or that they are able to withstand it. When we come to consider the possibility of not only organic but actually organised matter being developed out of inorganic matter, it seems to me that the supporters of such a view can hardly have understood the tremendous nature of the postulate they demand. The simplest combination in chemistry, such as the formation of a drop of water,

necessitates an enormous integration of force, as much, for instance, as would furnish a flash of lightning. The burning of a gramme of hydrogen evolves 35,000 heat units, of a gramme of carbon 8,000, equal, respectively, to 47·5 and 11 foot-tons. But these are the simplest of inorganic combinations. Conceive, therefore, what the nature and amount of force must be that is involved in the infinitely more complex integration of the most minute particle of organic matter, and the still more tremendous concentration of force required for the most minute organism capable of independent existence. It seems to me that, apart from the absence of direct evidence, there are philosophical grounds for questioning the possibility of such a thing, and yet we have had people ask us to believe that creatures as high in the scale as paramecia, or even acari, are capable of arising spontaneously! It is true that those creatures do appear at times very unexpectedly, but it is surely giving ourselves airs of omniscience to say, because we were not present at the birth, that, therefore, they had no parents!

The experiments of Chauveau, Sanderson, &c., have shown good cause for believing that there is a special poison in diseases,[1] and that that poison is particulate; that is, that although it be extremely minute, and act so little on light as not to render a fluid turbid, it still consists of separate particles, and is not merely dissolved and diffusible like a salt or albuminous substance.

[1] Some difference must be made between truly specific diseases, such as enteric fever, cholera, &c., and pseudo-specific, such as puerperal fever, diphtheria, and the like, the argument for a special poison in the latter not being as yet made out.

There are, however, observers who consider disease may be propagated without any poison, particulate or otherwise, ascribing its propagation to certain obscure influences—aërial, telluric, or cosmic ; if a special poison be admitted, that its action is controlled by, or even subordinated to, those other influences. Contagion is in those cases completely denied as a matter of course, and anomalies in the way of attack and subsidence of epidemics appealed to in support of their view. We have thus Dr. Bryden, in India, who insists upon aërial currents as the main cause, and believes that simple climatic fever may be converted into typhoid thereby. On the other hand, Dr. Lawson has promulgated his ingenious theory of pandemic waves, in which successive isolœmic curves (or curves of equal pestilence) are supposed to occur from south to north, local conditions more or less determining the particular kind of disease that arises in each county or district. I cannot go into a detailed analysis of those different views, but I may say that they have arisen from the fact that certain anomalies do exist in the history of epidemics. It seems strange that a disease should suddenly attack a community, rage for a time, and then decline, if the ordinary views of contagion be true. Therefore, it is not unnatural to look to some other more occult influence as the determining cause. It seems to me, however, that this is hardly so necessary as might at first appear. I am far from denying the possible existence of some such influences; but before resorting to them it would be well to examine existing conditions a little more closely. To take an instance,

Dr. Tripe has investigated the subject of scarlatina very carefully, and has shown the apparent existence of periodic waves, from which he concludes that there is some general cause beyond our control which determines their arrival. If curves[1] be drawn for the metropolis and England generally from his figures, it will be seen that the waves do exist; also that in the London curve, at least, there appears to be a sort of cycle of waves in addition. But it has been frequently pointed out that a severe epidemic exhausts the supply of epinosic individuals, and that, perforce, from want of pabulum there must be a lull until a fresh accumulation takes place. Now, it has seldom been considered how much the probability of invasion is increased by the increase of the epinosic element. Thus, if there be one epinosic individual in a community exposed to a contagion there are two chances only to be considered, namely, that he takes disease or that he does not; but if there be two individuals, then there are four chances, namely—

1	chance that	both take disease.
2	,,	one takes it.
1	,,	neither take it.

In the case of three individuals we have eight chances:

1	chance that	all three take it.
3	,,	two take it.
3	,,	that one takes it.
1	,,	none take it.

And so on until with ten individuals the number or

[1] These curves were shown on the black board.

chances becomes 1,024, of which only *one* is concerned with the perfect immunity of all ten. In fact, the chances of invasion are increased in the ratio :

$$p=2^x$$

where p is the probability and x the number of epinosic individuals.[1] It can hardly be wondered at, then, that an invasion should take place when a certain number of epinosic individuals are collected together; for, independent of the large number of chances above shown, it must be remembered that the occurrence of every successive case increases the chances of disease for the remainder. This is on the supposition that all the individuals are exposed to the contagion equally; but even if we suppose the contagion to be thrown at random among the community, the probability of its striking an epinosic individual is in the ratio of the number of such individuals, until certainty is reached, when they are all epinosic. The problem could be treated in other ways; but I think I have said enough to show the advantage of a careful investigation of facts before adopting a fresh hypothesis. The scientific history of epidemics has still to be written, but good work is being done in that direction; as an example of which I may specially name the valuable labours of Mr. Netten Radcliffe, whose enquiries have already thrown much interesting light upon the question.

Statistics.—At the bottom of all enquiries of the sort lies the science of statistics, one of the most

[1] See Tables XXI. and XXII.

valuable, the worst used, and the most abused, perhaps, of any that we apply to the solution of biological and social problems. It has been contemptuously said that figures will prove anything ; so they may to a fool or an ignoramus, or if false facts are registered. But statistics honestly collected cannot possibly lie ; and the error is chiefly in the hasty or erroneous inferences drawn. It is a great pity that mathematical science is so much neglected by our profession and so poorly taught to the community in general. I do not think it is the best training for the mind, but it is of great value, and intelligently used would frequently save men from rushing into errors that confound themselves and confuse their fellow-creatures. What, for instance, is more common than a crude generalisation from insufficient data, as in the treatment of disease? Let us suppose, for example, that a physician has ten cases of a certain disease which he has treated by means of a particular method, other things being equal ; the method has been successful in seven out of the ten ; how near is this to the true average ? Or, in other words, what will be the latitude of variation in say 100,000 cases ? By Poisson's formula[1] we find the probable error to be 0·4 to unity, or the error is greater than the number of unsuccessful cases ; so that in 100,000 the range would lie between 110,000 and 30,000, an obvious absurdity. Those ten cases alone then are valueless for establishing a true average. If, however, 100 cases be collected, out of which seventy are successful, the proportion is still the same, but the

[1] See Table XXIII.

error is much less, for it is now only 0·13 to unity, or in 100,000 cases the range would be between 83,000 and 57,000, still too great to establish a theory upon, but nevertheless a datum of some value. If 1,000 cases were collected, of which 700 were successful, the error would be only ·04 to unity, and the range in 100,000 cases between 74,000 and 66,000, a still closer approximation, whilst with 10,000 cases observed it would be between 71,300 and 69,700; with 100,000 cases between 70,400 and 69,600, and with 1,000,000 between 70,130 and 69,870, or very near certainty. We may draw two lessons from this: first, that a small number of observations is inadequate to establish a fact; second, that a mere repetition of observation beyond a certain point is proportionately of small value, and becomes in time useless, unless it be for the purpose of establishing new facts. This is obvious when we consider that the degree of accuracy increases only in the ratio of the square root of the number of observations; for instance, in the example already cited the error for ten observations was 0·4 to unity, and for 100, 0·13; now, 0·13 to 0·4 is just as the square root of 10 to the square root of 100, and so on. Thus, by increasing our observations from 100 to 10,000, we increase our accuracy ten times, but if we add another 10,000 observations we only increase our accuracy in the ratio of one to the square root of two, or less than half as much again; and in order to gain a tenfold greater accuracy we should have to raise our observations from 10,000 to 1,000,000. There is, therefore, a point beyond which mere repetition is

only waste of time. We might illustrate this very simply by pointing out that it would be perfectly useless to record deaths for the mere purpose of proving that men are mortal, for this has been proved already practically in countless millions of instances. It is true that even that vast experience is insufficient to enable us absolutely to say that no man ever will be immortal; but the nearer approach to accuracy gained by successive repetition is so infinitesimally small as to be perfectly inappreciable, hardly even admitting of numerical statement. It is a different thing, however, when we record the age at death, the disease died of, the situation at time of death, and the various other data affecting the circumstance. These all open out other roads of enquiry that lead successively to 'fresh fields and pastures new.' The more that statistics are extended, embracing fresh facts and analysing old ones, the more valuable will they be and the greater will be their *raison d'être*. Recently objections have been taken to the validity of the Registrar-General's returns, particularly by Dr. Letheby and Dr. Tripe, both as regards the inferences drawn and the special value of death-rate as a test of salubrity of a locality. With regard to the inferences, it seems to me that they are there to be accepted or not, as the reader thinks fit; the data from which they are drawn are given, and he may put his own interpretation on them as he likes. With regard to the other point bearing on the value of death-rate, as recorded, it is pointed out that there are many disturbing influences which render it valueless. It has, however, been conclusively demonstrated by

Mr. Humphry that even if the maximum of influence were accorded to those disturbing causes the differences resulting would be but small, whilst it is shown that those influences are actually taken into account as far as means at hand will allow. I cannot help thinking that the objectors have been hypercritical and that their difficulties are much less than they imagine. According to the law of probabilities, accidental causes acting through a length of time tend to neutralise each other; and this may be seen by the tables of chances in the Appendix.[1] The greatest number are for the case where the errors neutralise each other, and for excess or deficiency the chances are equal. Therefore, even admitting the existence of the disturbing influences referred to, they will tend to equalise each other if their action be constant, as from the nature of the problem we may infer it is. I have had occasion to notice this in a very interesting way in our class of practical hygiene at Netley. The pupils there are taken through a careful course of analysis, and each day we take down on the board the quantitative results and find the average. It is quite remarkable to find how near this is to the truth even when the discrepancies are considerable, the errors in excess and those in deficiency neutralising each other. I think, therefore, that if data are honestly collected and sufficiently numerous, averages give us a very fair approximation to the truth; but it would be advantageous from time to time to submit the series to mathematical examination, to see if the groups of facts

[1] See Tables XXI. and XXII.

correspond to the known mathematical probabilities. The proportions may be seen from the diagrams[1]; if the successive data depart very much from such proportions, then we may conclude that the data are not trustworthy. In this way Quetelet had no difficulty in pronouncing certain returns concerning French rejected conscripts to be false, and in determining the degree and direction of the error. Another way is the determination of the probable error, and from that the value of the series, thus: $v=\frac{1}{p^2}$, or the relative value is inversely as the square of the probable error. Were some of these methods followed we should not be treated, as we sometimes are, to such extraordinary vagaries in the shape of statistics, like some of those put forward by the opponents of the Contagious Diseases Acts. Some people in Germany, too, have even tried to prove by statistics that vaccination increases the liability to attacks of smallpox. Surely the 'farce of figures can no further go.'

I cannot do better than cite Quetelet's four chief rules, which ought to be hung up in every room or office where figures are dealt with :—

1. Never have preconceived ideas as to what the figures are to prove.

2. Never reject a number that seems contrary to what you might expect, merely because it departs a good deal from the apparent average.

3. Be careful to weigh and record *all* the possible causes of an event, and do not attribute to one what is really the result of the combination of several.

[1] See Tables XXI. and XXII.

4. Never compare data which have nothing in common. Were these rules adhered to the science of statistics would be much more valuable as well as much more respected than it now is.

I have not left myself much time for an eloquent peroration, so I will simply say that I hope I have been able, however imperfectly, to lay before you reasons for believing in a great future for sanitation, and that, if the State is to do its duty, this must hereafter be one of its chief cares. We, as a profession, on the other hand, have it in our power to strengthen the hand of the State in this matter. It has sometimes been objected that the care with which we prevent mortality will have a bad effect on the future of the race, by prolonging the lives of weakly individuals and allowing them to breed, and so interfering with the law of natural selection. But unless we judicially execute our weakly brethren, I do not exactly see what we can do! Again, if death struck down only the weakly, the objection might be valid, but it often lays low our best and greatest. There is this also to be said, that we try to prevent disease as well as death, and that if we can do this and so induce hereditary immunity, there is no reason why our weakly ones of to-day may not be the parents of a strong and intellectual race in the future. Under any circumstances our duty is clear—to improve the condition of our race according to our lights, and let results take care of themselves. The same law of development will, sooner or later, teach us if we have taken the right road or not to reach the wished-for goal.

APPENDIX.

Table IX.

Quantity of water (supplied per head in different places) in gallons daily.

London :	New River Company	23	mean about 28.
,,	East London	22	
,,	Chelsea	33·8	
,,	West Middlesex	30	
,,	Grand Junction	34	
,,	Southwark and Vauxhall	21	
,,	Lambeth	34	
Southampton		35	
Glasgow		50	
Edinburgh		35	
Liverpool		30	
Sheffield		20	
Nottingham		17	
Derby		14	
Norwich		12	
Soldiers in barracks		15	
Paris		31	
New York		300	
Ancient Rome		350	

TABLE XIII.

Deaths from phthisis diminished in consequence of the drying of the subsoil by improved drainage (Buchanan).

	Per cent.
Salisbury	49
Ely	47
Rugby	43
Banbury	41
Worthing	36
Leicester	32
Newport	32
Macclesfield	31
Cheltenham	26
Bristol	22
Dover	20
Warwick	19
Croydon	17
Cardiff	17
Merthyr Tydvil	11

TABLE XIV.

Soils as regards power of retaining heat, 100 *being assumed as the standard* (Schübler).

Sand, with some lime	100·0
Pure sand	95·6
Light clay	76·9
Gypsum	73·2
Heavy clay	71·1
Clayey earth	68·4
Pure clay	66·7
Fine chalk	61·8
Humus	49·0

TABLE XV.

Soils in order of healthiness.

	Slope	Permeability to water	Emanations into air	Substances into water
Primitive and metamorphic rocks (when unweathered) .	Great, usually	Slight	None	Few
Clay slate	,, ,,	,,	,,	,,
Millstone grit, hard oolite formations	Moderate	,,	,,	,,
Gravel and loose sands, without impermeable subsoils .	Slight	Great	Slight	Variable
Chalk, not marly . . .	Moderate	,,	,,	Lime salts ; a little magnesia
Sandstones, old and new .	,,	Variable, but usually considerable	,,	Variable, often great ; alkaline and earthy salts ; organic matter
Limestones, old and new .	Considerable	Moderate	,,	Rather considerable ; lime salts
Magnesian limestone, dolomite, &c.	Moderate	,,	,,	Considerable ; lime ; magnesia
Sands, with impermeable subsoils	Slight	Arrested by subsoil	Considerable	Variable, often great ; alkaline salts ; some lime
Clays ; marls ; mixture of sand and clay ; most alluvial soils	,,	Slight	,,	Often great ; alkaline and earthy salts ; organic matter
Marshes (when not peaty) .	,,	,,	,,	Great ; salts ; organic matter

TABLE XVI.

Work done, calculated from the squares of the velocity; 3 miles an hour = unity.

Velocity in miles per hour	Ratio 3 miles an hour = 1·000	1 mile = foot-tons	Amount required to equal 300 foot-tons.					Maximum at one time to equal 3 miles an hour.					Period of rest	
			Distance		Time			Distance		Time				
			miles	yds.	hrs.	min.	sec.	miles	yds.	hrs.	min.	sec.	min.	sec.
1	0·111	2·1	143	246	143	9	0	—		—			—	
2	0·444	8·4	35	1,382	17	53	3	—		—			—	
3	1·000	18·9	15	1,628	5	18	30	3	0	1	0	0	0	0
4	1·778	33·6	8	1,648	2	14	0	1	1,174	0	25	0	35	0
5	2·778	52·4	5	1,296	1	8	4	1	141	0	12	58	47	2
6	4·000	75·5	3	1,711	0	39	43	0	1,320	0	7	30	52	30
7	5·444	102·8	2	1,617	0	25	0	0	970	0	4	48	55	2
8	7·111	134·2	2	429	0	16	50	0	743	0	3	10	56	50
9	9·000	169·9	1	1,347	0	12	46	0	587	0	2	13	57	47
10	11·111	209·8	1	757	0	8	35	0	475	0	1	37	58	23
20	44·444	839·1	0	629	0	1	4⅓	0	119	0	0	11⅘	59	48⅕
22	53·778	1015·3	0	520	0	0	43⅓	0	97	0	0	9	59	51

Table XVII.

Potential energy required for active work in foot-tons.

$$\left.\begin{array}{r}\text{Internal work}\\\text{Man at rest}\end{array}\right\}=\left\{\begin{array}{l}\text{Work of heart, \&c.}=\ \ 260\\\text{Animal heat, \&c.}\ \ =2555\end{array}\right\}=2815.$$

Active work	Potential energy necessary for active work alone	Total work, including internal, to be provided for by food	Ratio of active to total work
300·	1500	4315	1 : 14·38
450·	2550	5365	1 : 11·92
525·	3225	6040	1 : 11·50
562·5	3638	6453	1 : 11·47
581·2	3882	6697	1 : 11·52
590·6	4023	6838	1 : 11·58
595·3	4102	6917	1 : 11·62
597·6	4146	6961	1 : 11·65
598·8	4170	6985	1 : 11·66
599·4	4183	6998	1 : 11·68
599·7	4190	7005	1 : 11·68
599·8	4194	7009	1 : 11·69
599·9	4196	7011	1 : 11·69
600·0	4197	7012	1 : 11·69

TABLE XVIII.

Work done, calculated from carbonic acid expired ; man weighing 160 *lbs.*

Velocity	Ratio of air inspired	Carbonic acid expired per hour in cubic feet	Energy in foot-tons	Ratio rest = 1	1 mile equal to foot-tons	Remarks
Rest . . .	1·00	0·716	117	1·00	—	These calculations have been worked out from the late Dr. Edward Smith's results. The rate for five miles is interpolated. It is to be noted that at 3 miles an hour the expenditure per mile is at its *minimum*.
Sitting . . .	1·18	0·861	141	1·21	—	
Standing . . .	1·33	0·995	163	1·40	—	
Walking :—						
1 mile an hour .	1·90	1·446	237	2 01	237	
2 miles an hour .	2·76	2·530	415	3·53	208	
3 ,, ,, .	3·22	3·275	538	4·58	**179**	
4 ,, ,, .	5·00	5·720	936	8·00	235	
5 ,, ,, .	6·00	8·300	1360	11·65	272	
6 ,, ,, .	7 00	11·425	1875	16·00	312	

TABLE XXI.

Table showing the chances of 10 *events, positive or negative.*

Nature of event		Chances	Nature of event		Chances
Positive	Negative		Positive	Negative	
10	0	1	4	6	210
9	1	10	3	7	120
8	2	45	2	8	45
7	3	120	1	9	10
6	4	210	0	10	1
5	5	252			

The maximum of chances is for the case where the events are equally positive and negative and neutralise each other; also the chances for excess of positive are exactly equal to those for excess of negative. The numbers of chances are obviously the successive co-efficients of an equation of the 10th degree.

TABLE XXII.

Table showing the chances that, out of 16 *balls drawn from an urn, containing an equal number of white and black, but an infinite total number, the following will be black* (Quetelet).

No. of black balls in the 16 drawn	Chances	No. of black balls in the 16 drawn	Chances
0	0·00002	9	0·17456
1	0·00025	10	0·12219
2	0·00185	11	0·06665
3	0·00854	12	0·02777
4	0·02777	13	0·00854
5	0·06665	14	0·00185
6	0·12219	15	0·00025
7	0·17456	16	0·00002
8	0·19638		

TABLE XXIII.

Poisson's Formula.

$$\frac{m}{\mu} \pm 2\sqrt{\frac{2 \cdot m \cdot n.}{\mu^3}}$$

Where $\mu =$ total number of events.
,, $m =$,, of positive events.
,, $n =$,, of negative events.

Or it may be stated thus :

$$\frac{p}{q} \pm \sqrt{\frac{8 \cdot p(q-p)}{q^3}}$$

Where $q =$ total number of events.
,, $p =$,, ,, in a particular direction.

For mean error.

1. Find the *mean* of the series of observations; find the *mean* of all the observations *above* the mean, and subtract the mean from it: this gives the mean error in excess. 2. Find the mean of all the observations *below* the mean, and subtract it from the mean: this gives the mean error in deficiency. Add the two quantities and take the half: this is the *mean error.*

For error of mean square.

Find the sum of the squares of apparent errors : this is done by taking the sum of the squares of the observations and subtracting from it the square of the mean multiplied by the number of observations : then calling this result S we have (n being the number of observations) :—

$$\text{Error of mean square} \begin{cases} \text{of a single measure} = \sqrt{\dfrac{S}{n-1}} \\ \text{of the result} \qquad = \sqrt{\dfrac{S}{n(n-1)}} \end{cases}$$

For probable error.

Multiply the error of mean square by 0·6745.

(*See* Airy's 'Theory of Errors of Observation;' Kohlrausch's 'Physical Measurements;' and other works.)

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* ἐπίνοσος, *morbo obnoxius.*

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